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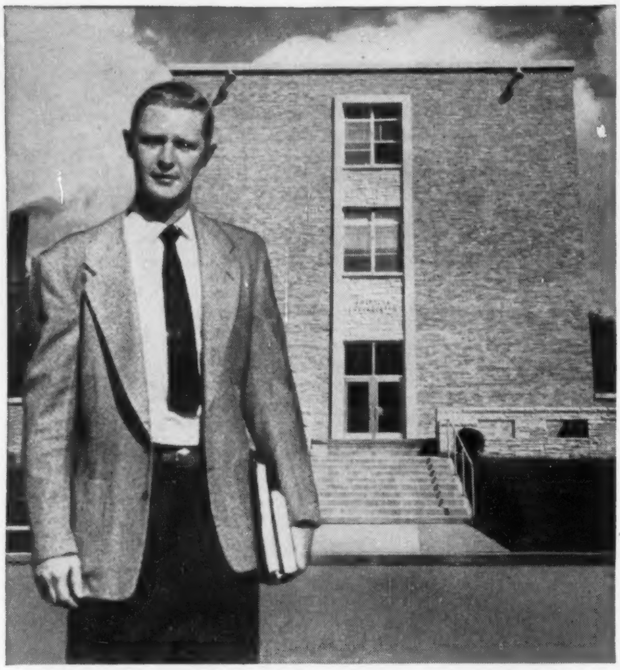

Delbert N. De Young received a B.S. in Chem. Eng. from the University of Wisconsin last June. Now he is working for an M.S. degree. By asking questions, he's learned that many excellent industrial opportunities are passed over because they're not understood by the average undergraduate.

Del De Young wants to know:

What sort of work is involved in technical sales at Du Pont?

Clarence D. Bell, B.S., Chem. Eng., Univ. of Pitts. (1937), joined Du Pont as a chemical engineer immediately after graduation. He began in the research group of the Ammonia Department, progressed steadily through assignments on nylon and a number of other products. Today he is an Assistant Director of Sales in the Polychemicals Department.

Clarence "Ding" Bell answers:

Well, if I said "All sorts," it might sound a bit vague to you, Del, but it would be very close to the truth. That's because technical sales work at Du Pont—bearing in mind the great diversity of products we have—is broader in scope than a lot of other technical assignments, and requires additional talents.

Let's suppose that one of Du Pont's customers is having technical difficulties—needs help in adapting "Teflon" to a specific gasketing application, for example. When our sales representative calls, he naturally must carry with him the engineering knowledge that's the basis for sound technical advice—data on flexural fatigue, chemical passivity, and deformation under load. The customer is receptive. He wants to make a better product, increase his sales, reduce costs—or do all three. Naturally, he's looking for reliable technical advice and intelligent actions that apply to his specific conditions. With the cooperation of the customer and help from our own research people, when necessary, the problem will sooner or later be "licked."

We have found, though, that if a technical service man is going to be *truly* effective in such a situation, he must possess certain *human* qualities in addition to his technical ability. That is, he must really *like* people and be sincerely interested in helping them solve their problems. He must—in every sense of the word—be an "ambassador" who can handle human relationships smoothly and effectively.

Take the depth suggested by this simple example, Del, and multiply it by a breadth representing all the challenging problems you'll run into with Du Pont's diversity of products. If your slide rule isn't too far out of alignment, the resulting area should give you some idea of what I meant by "all sorts" of work.

Let me emphasize one more point. The importance of effective sales work is fully understood and appreciated at Du Pont! In the past, sales work has been one of the active roads to top management jobs. There is every reason to believe that this will continue in the future.

Are you inclined toward sales work? There are four main types of sales activity in the Du Pont Company—technical sales service, sales development, market research and direct selling. Information on sales, and many other facts about working with Du Pont, are given in "The Du Pont Company and the College Graduate." Write for your copy of this free 36-page booklet to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.

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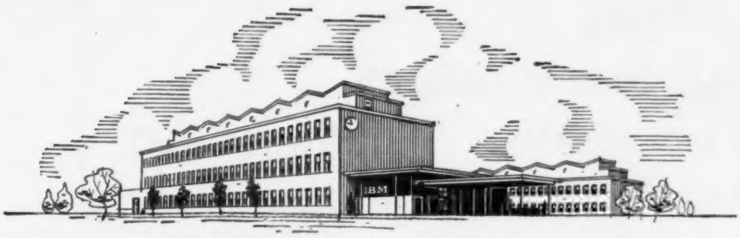

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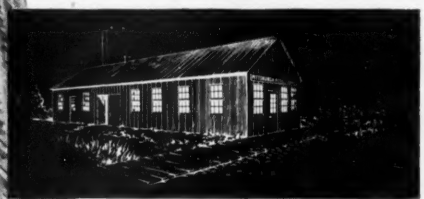

Founded 1885

THE CORNELL engineer

DECEMBER, 1954 — VOLUME 20 — NUMBER 3

COVER—Libe Tower as seen from Tower Road

—Matt Starr

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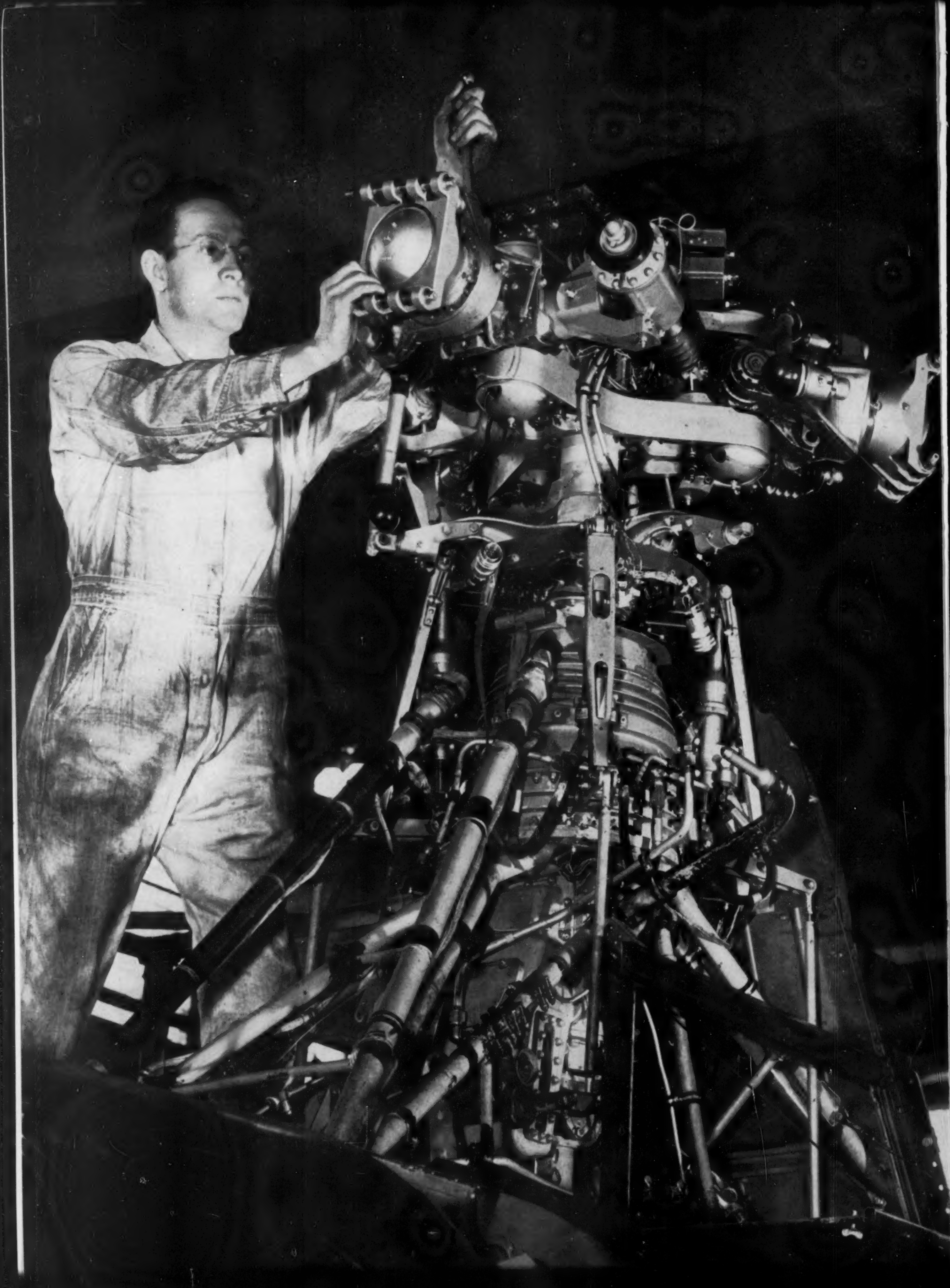

Problems in Helicopter Design

by ARTHUR H. VAUGHAN, EP '57

Note: Following in the January, 1955, CORNELL ENGINEER, Part II of this article will be devoted to the general problems of stability and control, rotor configurations fuselage, and internal mechanisms.

The principal advantage of the helicopter over other types of aircraft is the independence of lift and flight-control from forward horizontal motion. The helicopter is thereby capable of vertical and stationary flight. These maneuvers are at a premium in military and commercial applications and have attracted the attention of experimenters and engineers since the time of da Vinci.

The reason for this, perhaps, was that helicopter flight seemed a novel amusement, as it indeed is.

Only during the past sixteen years, however, have helicopters having satisfactory performance and stability characteristics been designed and built. Their success is largely due to improved power plants, increased understanding of aerodynamics (especially of rotating-wing effects), and the large backlog of experience of early unsuccessful helicopter builders. The present-day helicopter is still relatively undeveloped when compared with modern aircraft standards, and so promises fertile area for theoretical and experimental research, as well as improvement in the "art" of design and construction of helicopter parts.

For this article the general lifting-rotor subject has been divided into three broad classifications: performance characteristics, blade control mechanisms, and blade construction; and will be presented in approximately that order.

Improvement in helicopter handling characteristics by means of artificial stability and control devices.
—Cornell Aeronautical Laboratory

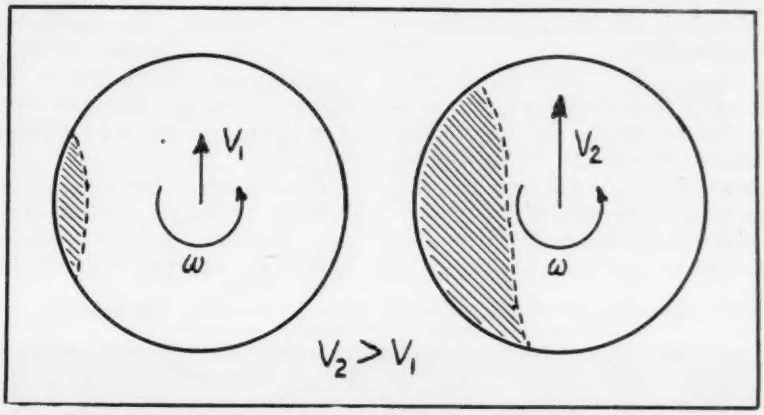

Fig. 2. Blade Stall pattern schematically illustrated at two stages, showing growth of the stall (shaded area) from the blade tips. Top view.

Rotor Theory

Several methods of calculation have been evolved for estimation of propeller characteristics, and a few of these have been applied to the rotating wing with good correlation of experimental data. An essential difference, however, of helicopter rotors from airplane propellers is that in the hovering or descending flight condition no true slipstream is formed, and a slipstream is the basic consideration of most propeller theroies. Instead, the rotor develops the so-called "vortex-ring condition" when the air passes downward through the disc of the rotor and returns upward around the outside edge of the disc. The vortex ring condition does not lend itself to accurate estimation by conventional propeller theories. A second complication arises in connection with horizontal flight, when airflow is not parallel to the rotor axis. These difficulties are fundamental and have received (and are still receiving) a great deal of study.

It might be mentioned that most problems in aerodynamics are solved only after making judicious simplifications. The entire picture of rotor performance is of course considerably complicated by the large number of variables involved. For this reason, a good, dependable framework of theory is necessary to indicate major design criteria and to form a suitable basis for effective experiments. Research organizations such as the National Advisory Committee for Aeronautics (NA CA) have a large output of work along this line.

Stall Behavior

The value of the helicopter would be considerably enhanced if the top forward speeds of present-day models, on the order of 150 mph, were higher. (The Sikorsky XH-39 has flown 156 mph, the present record.) The principal limiting factor in top forward speed is inherent in the behavior of the rotor itself: as the forward speed of the craft is increased, the retreating blade encounters progressively lower relative air speeds, whereas the advancing blade encounters higher air speeds. Thus a rolling moment is

set up by the resulting differential lift across the disc.

Two methods are commonly employed to remove or alleviate this effect of motion. The first is to hinge each blade at the hub so as to permit "flapping" up and down of the blades, or else to let the hub (of a two-bladed rotor) "see-saw" on the rotor axis. Thus attached, the blades can transmit no moment to the rotor axis. Centrifugal force will tend to keep the disc horizontal, although it will tilt toward the retreating side.

Some people build the flapping hinge (called the delta hinge) non-perpendicular to the longitudinal blade axis, so that the up-flapping advancing blade will have its pitch automatically reduced, while flapping down reduces the pitch. This tends to equalize the lift forces across the disc. See fig. 4.

When flapping hinges are used in a rotor system, it becomes necessary, in high speed flight, to use also another set of hinges called "lap hinges". It is necessary, because in flapping the blade centers-of-gravity vary in radial distance from the axis of rotation of the rotor system (closer when up-flapped than when horizontal), thus producing simply a manifestation of the law of conservation of angular momentum. The up-flapped blade needs to be free to swing ahead of the others, and so on. Severe vibrations will occur when flapping hinges but not lag hinges are used.

Nevertheless, successful hubs lacking lag hinges are sometimes used to meet specialized requirements—for example, high lift and low forward speed—where lag forces are not a problem.

Fig. 3. An engineer at C.A.L. inspects the pulse jet mounted on the helicopter rotor blade of the Laboratory's new whirling-arm test facility.

—Cornell Aeronautical Laboratory

The second method of alleviating differential lift effect is known as "cyclic pitch control" and will be discussed later. This is functionally equivalent to blade hinging; but pitch control is obtained by cyclic adjustments in the hub mechanism, a more sophisticated and controllable arrangement.

It follows that at high speeds the retreating blade has a high angle of attack and a low relative air speed, so that at top speed, the tip area of the retreating blade must reach a stall. The stall pattern is illustrated in figure 2 at two stages. The stalled area rapidly grows from the tip to become severe, causing short-period vibration and loss of control by the pilot. It may be noted that in airplanes, stall presents a lower rather than an upper limit for forward velocities.

Overcoming Stall

When once the stall characteristics of lifting rotors in horizontal motion were recognized and understood, much attention was given to designs capable of delaying the effect. One rather obvious step was to produce blades with very smooth surfaces to prevent premature stall due to blade irregularities.

Another way to delay the stall was indicated several years ago by studies on models (as well as by theory), and it is to build a moderate twist and a taper into the blades so that tip sections may work at lower angles of attack than central sections. An increase of about 10 per cent in top limiting speed has been found possible with the use of a –8 degree blade twist. Alternatively, twist and taper result in a slight increase of efficiency in the unstalled condition in some cases. In other cases there is at least no decrease in efficiency. In hovering flight, rotor induced losses amount to about 75 per cent of total power loss; this may be reduced to about 55 per cent if the blades are twisted and tapered properly. For these reasons blade twist and taper is the subject of considerable investigation.

The use of various "high-lift" devices and fixed lifting surfaces (wings on the fuselage) to unload the rotor (and thus delay the stall)

as forward speed is increased are considered fertile topics for future research, and should facilitate speeds in excess of 200 mph.

Certain advantages are represented by high rotor rpm at high forward speeds: the stall of retreating blades is delayed as the ratio of forward speed to tangential tip speed decreases. High rpm is most efficient at high forward speed. (Conversely, low rpm at low forward speed or in hovering is most efficient.) Up to this point, however, compressibility effects on the *advancing* blade and growth of the boundary layer over the upper airfoil surface with consequent loss of lift (see Scientific American, August 1954, *The Boundary Layer*) have given additional limitation to the speeds of high-rpm helicopters.

A typical tip velocity, incidentally, is on the order of 400 fps.

Attempts have been made to design blades having high critical Mach numbers. For a given stalling angle, a high critical Mach number will allow operation at higher gross weight because it permits the use of higher tip speeds.

Handling Qualities

In its present stage of development the helicopter is different and more difficult to fly than most fixed-wing airplanes. Perhaps the most important research problem at the present time is the improvement of helicopter stability and control characteristics, and its flying and handling qualities.

It is generally agreed as a result of theoretical work and flying experience that if a helicopter is disturbed while hovering (as by a sudden displacement of the control stick), and if the stick is then held fixed in the neutral position so that no correction for the disturbance is made, the helicopter will oscillate about its original hovering position, and this oscillation will increase with time. Thus the helicopter is dynamically unstable. Very often the circumstance is no problem to the pilot.

However, some undesirable stability characteristics do present themselves, especially to inexperienced pilots. These are, in two examples, high control sensitivity and un-natural stick-force gradients. Recently helicopters have been in use which have excellent stick-free performance in undisturbed flight. In particular, Bell Aircraft helicopters use a gyroscopic stabilizer bar, located below the main rotor blades at 90 degrees to the blades. If while hovering the helicopter is displaced by a gust or control movement, the bar, tending to remain in a fixed plane due to gyroscopic effects, will by means of a lever assembly, feather the rotor blades in such a manner as to bring the helicopter back to its original hovering position. Certain other tricks have been developed, but information on some of them is difficult to obtain because manufacturers do not always care to give away their secrets.

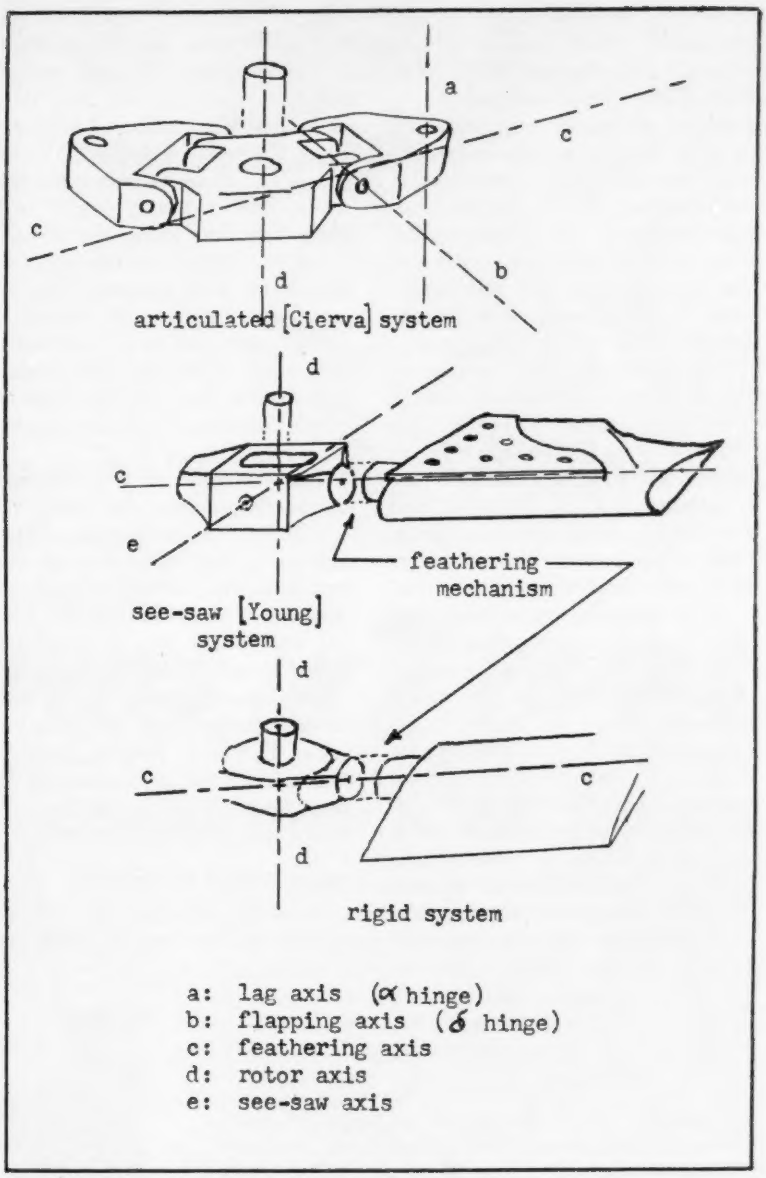

Fig. 4. Non-detailed illustration of the three basic types of rotor systems.

In the partial-power vertical-descent region of flight between approximately 500 and 1500 feet per minute, the unsteady vortex-ring type of airflow through the rotor disc causes violent, random, and often dangerous yawing motions of the helicopter and rotor. The phenomenon is simple enough to recover from if experienced at sufficiently high altitude, but it illustrates the nature of yet-unsolved stability problems.

Vibration

Another highly disconcerting phenomenon related to vibrational

stability is what is called "ground resonance", which occurs in helicopters having lag and drag hinges. Essentially, ground resonance is the result of an aerodynamic coupling of blade vibrations with the ground while the helicopter is accelerating its rotor for take-off; at the resonant frequency, the vibration coincides with the natural frequency of the landing gear, and this occurance has been responsible for the destruction of several helicopters.

The trouble has been avoided on late models by proper mechanical damping devices on the blade hinges (these may be seen in figure 1), by proper choice of landing structure frequency, and by knowing and avoiding critical rotor rpm's. Ground resonance need no longer be a serious problem, as it once was.

It is generally understood that where large, heavy, rotating masses are involved, vibrations are bound to occur. This is no less true in the helicopter, where the blades, in addition to being large and heavy, are flexible, hinged, and subject to varying aerodynamic forces. Vibration remains as perhaps the most unpleasant defect in present helicopters. It produces noise, passenger discomfort, pilot fatigue, and it is a risk from the standpoint of structural fatigue. Vibrations tend to become worse at high speeds.

The existence of large periodic forces exciting the first two, three, or four bending modes of helicopter rotor blades is recognized. The origin of the forces is under question. They occur at multiples of 3 to 10 times the rotor rpm. The designer must be able to estimate the magnitude of such harmonic bending moments (which are sometimes quite high), and he is faced with a somewhat controverisial subject; one which has recently received much theoretical study by members of the NACA.

Blade stability is a prerequisite to the general dynamic stability of a helicopter, and two types of blade instability are sometimes encountered: flutter (in any blade), and weaving (in see-saw blades). Flutter may occur also in fixed-wing aircraft and is corrected by proper chordwise mass balance. Weaving is more complex and has presented some difficulty. Weaving gets its name from the appearance of the irregular path which the blade tips follow when improperly rigged.

Blade Control Mechanisms

As can be seen from figure 1, the machinery for manipulating the pitch in rotor blades is extremely complicated. The cost of designing such apparatus is high.

A survey of helicopter history reveals that there are three basic types of rotor systems, distinguished by the manner in which the blades are attached to the hub, and these are sketched in figure 4 to indicate their rudiments. The fixed type, or rigid system, has been used on early machines, but it is hardly practical due to bad vibration, control, weight, and bending stress problems. Consequently, rigid systems are no longer in use.

The two remaining contenders, the "see-saw" or Young system and the articulated or Cierva system, have been referred to earlier in this article. The helicopter industry is too young, many people believe, to have yet proven that one of the two is definitely superior. Very likely both will continue to be used for some time. Below are several comments on the Young and Cierva systems intended to point out their relative advantages.

Young (2-bladed "see-saw")

1. High bending stress at blade roots.
2. Blades are easy to "track" for vibration study and balancing
3. Being a two-bladed rotor, it can have heavier blades, and thus store more energy for power-off descent; needs less power to carry a given load.
4. Needs no special damping provisions.
5. Stores in small space without folding of blades.
6. Simple design, resulting in reduced maintenance.

Cierva (3 or more bladed, articulated).

1. No root bending stresses except those introduced by damping devices.
2. Relatively free from vibration.
3. More blades to manufacture, balance, and maintain. Must be light: store less energy.
4. Blades must be foldable for storage in small space.
5. Difficult to make starts under high wind conditions (Need special damping provisions).
6. Complex hub, bearing, control, lubrication problems.

Choice between the two is made

(Continued on page 42)

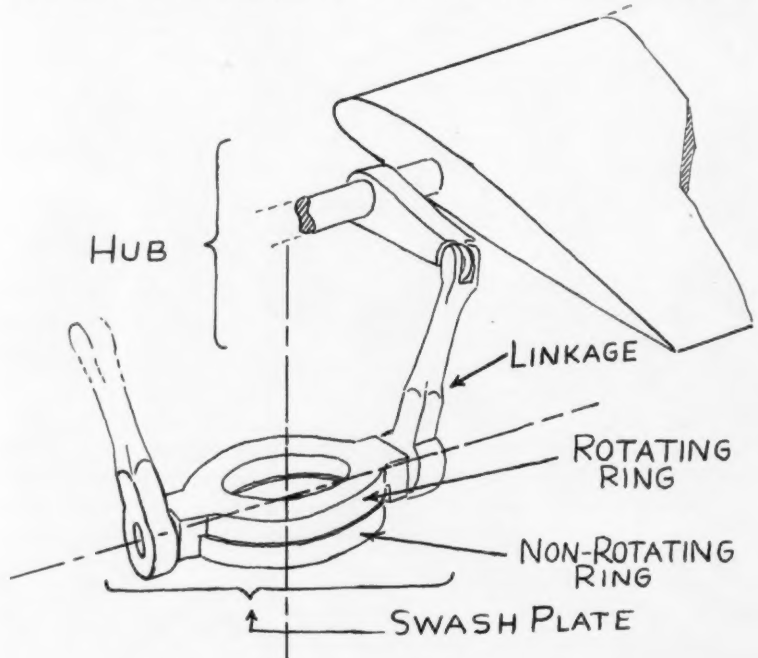

Fig. 5. A typical mechanism for accomplishing cyclic pitch control on helicopter rotor systems. The swash plate is tilted by control rods to the cockpit. The "rotating ring" is forced to rotate by means of connection with the rotor shaft.

Inspection of Telegraph Material

by BERNARD POMERANTZ, M.E. '45

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Bernard Pomerantz

ABOUT THE AUTHOR

Mr. Pomerantz attended Cooper Union School of Engineering and graduated from Cornell University in 1945 with a degree of B.S. in Mechanical Engineering. After service in the U. S. Navy, in 1946 he entered the Material Inspections Engineer's office, Plant and Engineering Department, where he has been concerned with material inspection and associated engineering problems. M. Pomerantz is a member of the ASME and the American Society for Quality Control.

An efficient organization capable of inspecting a great variety of products is an essential part of any large industrial establishment. The importance of material inspection in the Western Union system can be appreciated when it is realized that the Company's expenditures for new apparatus since World War II have exceeded $100,000,000 in value.

Primarily, the purpose of inspection is to insure that all material furnished to the Company under contract or purchase order terms complies with the requirements of specifications and arrives at its destination in the same physical state as when accepted. In a non-manufacturing corporation such as Western Union, the main concern is "procurement" or "vendor inspection". The Material Inspections Division has been developed to provide an efficient organization capable of inspecting an extreme variety of products ranging from heavily armoured ocean cables to magnet wire, from insulator pins to radio beam towers, and including carrier bays, teleprinters, facsimile machine, solder and soap. These items, which are purchased from about 200 vendors, must all satisfy rigid requirements of the telegraph system.

Because of the geographic dispersion of Western Union suppliers, it has been expedient to establish two main inspection areas, at New York City and Chicago, to simplify the inspection task. A third inspection area, limited chiefly to timber products, is centered about Shreveport, Louisiana, which is the principal source of line poles and crossarms for the Company. These three areas are all under the supervision of the Material Inspections Engineer whose headquarters is in the main office of the Company in New York City.

The inspection function begins with receipt of a copy of an order or contract from the Purchasing and Stores Department. Depending upon the conditions of the order and the classification of equipment, a decision is made as to whether inspection may be waived, or is required either at destination or at the source of manufacture.

If inspection is to be waived, the supplier will be instructed to ship the subject material without inspection. Such action is generally taken on small items such as name plates, screws, nuts, and so forth, or commercial items and inexpensive parts of simple design intended for noncritical usage, which are supplied at locations that are not readily accessible. Inspection may sometimes be waived on wire orders, in which cases the reliability of the supplier must be well established and he must accept liability for the quality of the material delivered.

If inspection is to be performed at destination, the supplier is so advised. Such inspection will usually be performed at convenient destination points, generally the Jersey City and Chicago Warehouses as they are easily accessible to inspectors.

Orders for material that is to be source inspected are distributed between the New York City and Chicago offices depending upon the location of the supplier. Such material can be divided into three classifications, as follows, depending upon the complexity of the purchased item, the quantity of material involved, and the total value of the equipment.

1. Spare parts and nonfunctioning equipment which are inspected for applicable features such as dimensions, mechanical, chemical and electrical requirements, assembly, workmanship, marking, quantity, and packing.
2. Complex assemblies and simple functioning equipment such as rectifiers, relays, motors, and electronic timers, which are subjected to inspection for applicable features of the foregoing list, and which in addition may be required to pass a performance or operating test.
3. Complex functioning equipment of Western Union design, such as numbering machines, printers, reperforators, carrier and telefax equipment, which are subjected to the same inspection as the previous items, and in addition must pass a performance or op-

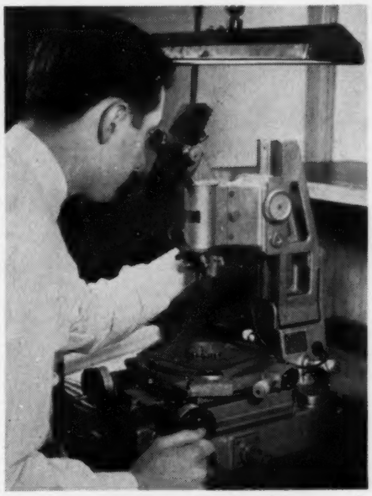
erating test. Normally, items in this category require the services of a resident inspector at the supplier's plant to inspect piece parts and subassemblies during the manufacturing period.

Specification requirements demand that equipment be inspected thoroughly prior to acceptance. This involves one or more of the following categories of inspection:

(a) Visual inspection for finish and workmanship.
(b) Dimensional inspection.
(c) Electrical tests for resistance, inductance, capacitance, insulation resistance, and continuity.
(d) Chemical tests
(e) Physical tests
(f) Operating and performance tests

(a) Visual inspection is perhaps most difficult to carry out with uniformity as it necessarily is dependent upon the personal judgment of the inspector. Opinions of different inspectors, as well as those of the vendors, may vary considerably because of varying experiences. Interpretations of surface roughness requirements, in particular, are very difficult unless some comparison standard is used to permit classification of the varying degrees of roughness normally encountered in machines work. Such a standard is the General Electric Standard Roughness Scale which provides actual samples of ten degrees of surface roughness varying from 4 to 2000 microinches average. These values of roughness represent the average deviation from a center line on a profile contour of the surface. Comparison of a finished surface with the samples will allow an inspector to judge properly the roughness classification of the unknown surface, thus permitting positive acceptance or rejection. In a very similar fashion, sample chips taken from the Federal Color Specifications are now used to standardize Western Union sign colors.

(b) Measurements of dimensions can be made as accurately as desired if proper tools and instruments are provided, and the time for performing the task is available; however, inspection measurements are normally desired quickly and to a limited degree of accuracy. The

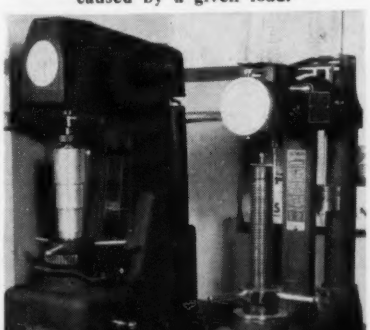


Checking a geneva wheel with a toolmaker's microscope.

basic measuring tools for such work include the steel scale, the micrometer, the vernier caliper, the thickness gage, the vernier height gage, the dial indicator and the surface plate. All of these instruments are measurers of variables which inform the operator of the exact measured dimension.

There is another classification of inspection measurement wherein fixed limit gages are employed. One class of fixed limit gages is the familiar "Go Not-Go" type which indicates whether the part being measured is acceptable, or undersize, or oversize. Such gages measure attributes and are normally single purpose tools commonly used on large production runs for checking one dimension only. The fixture gage is another of this type and is designed to check a number of critical dimensions simultaneously while the part is within the nest provided

Rockwell Hardness Tester, for testing metals by measuring the penetration caused by a given load.



for it. If any dimension is out of limits, the part will not fit and will be rejected.

To measure small parts of any shape, a toolmaker's microscope may be used. This instrument is essentially a microscope with a special measuring stage for reading coordinate dimensions directly with the aid of micrometer screws calibrated to read in ten-thousandths of an inch, and angular dimensions directly through use of a 360-degree rotary stage calibrated to read in minutes of arc. It is an exceptionally versatile tool and enables measurements to be made within a fraction of the time required with surface plate inspection methods.

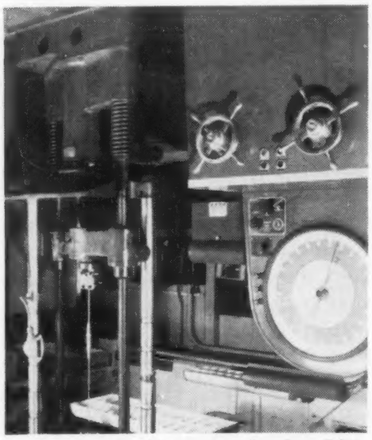
It is extremely important in any inspection work that standards of measurement be available to check the tools of inspection, since no instrument will remain accurate with routine use. Normal wear, without any abuse at all, will necessitate that corrections be made to micrometers and vernier calipers. The basic linear standards in inspection work are gage blocks which are accurately finished blocks of hardened steel having absolutely flat and parallel gaging surfaces within an accuracy to 0.000004 inch per inch of length. The correct use of such blocks obviates the possiblity of any disagreement ever occurring with regard to ordinary linear measurements. They are the basis of our mass production system requiring interchangeability of parts, as they are a never-varying standard available to every manufacturer.

(c) The basic measuring instruments used for electrical testing are voltmeters, ammeters, wattmeters, Wheatstone bridges, impedance bridges and decibel meters. These instruments measure circuit conditions and electrical values of components. To provide the necessary power for measuring purposes, standard power supplies such as rectifiers and oscillators must be available.

For elaborate and complicated operating tests, the cooperation of the Engineering Laboratories and personnel is often required. This is true, for instance, in connection with Klystron tubes for the radio beam system which can be tested, at the present time, only in the

Radio Beam Laboratory. It applies also to high voltage electrical tests on equipment, such as lightning arresters, which are conducted in a special laboratory for high voltage studies. If required, these facilities are all available for inspection purposes.

(d and e) Inspection for chemical and physical properties is performed on representative samples of the materials, as it is generally not practical to test the entire lot. Such tests are intended to guard against process failures and are



Testing the holding strength of a 5/16-inch strand cable grip on a universal machine.

very satisfactory as such. Chemical analysis tests for items such as solder, soap, and creosote are performed in the Chemical Laboratory of the company, Physical tests for hardness or strength of materials are performed in the Metallurgical Laboratories where Rockwell hardness machines, a durometer instrument, a universal testing machine, and a fatigue strength testing machine are available. Microscopes are used to examine and, in conjunction with a camera, to photograph etched and polished specimens to observe the structure of materials and in some instances, the depth of case in special hardness treatments.

Rockwell hardness machines are used to test the hardness of metals and similarly hard materials. The hardness number of a specimen under test appears upon the scale of the instrument and indicates the resistance of the material to penetration by a steel ball or diamond point of specific size and shape and under a calibrated load.

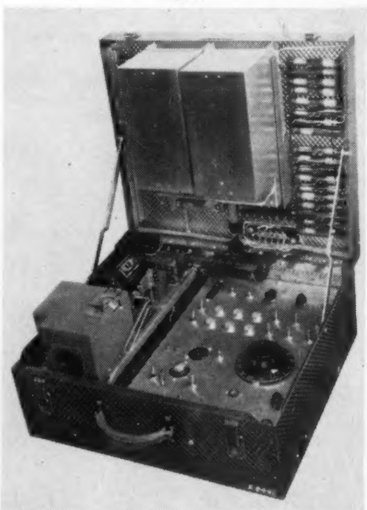
The durometer is another type of hardness testing machine used on relatively soft materials such as felts, rubbers and certain plastics. Its reading is also based on resistance to penetration properties of the material being tested.

The universal testing machine may be used to measure the tensile strength of wire, rod or cast metal speciments or the compressive strength of concrete blocks or columns. With this information and the physical dimensions of the samples known before and after the test, the elongation and Young's Modulus of Elasticity can be computed.

For testing paper[1], which is an item of prime importance to the operation of the telegraph system, a special humidity controlled room is available and is equipped with special instruments for measuring the tearing, bursting, and stiffness characteristics of the material.

(f) No matter what inspection may be performed on operative equipment in its static state, an operating test is required before acceptance. Items such as tape transmitters, numbering machines, printers, and Desk-Fax require special telegraph circuits and eqiupment for their operation. It is therefore necessary that convenient test circuits be designed as semi-portable test table units that will duplicate as closely as possible the actual service conditions the equipment is expected to meet. By operating the unit for a specified length of time,

Portable test set—designed to perform operating tests on Distributor-Transmitters.



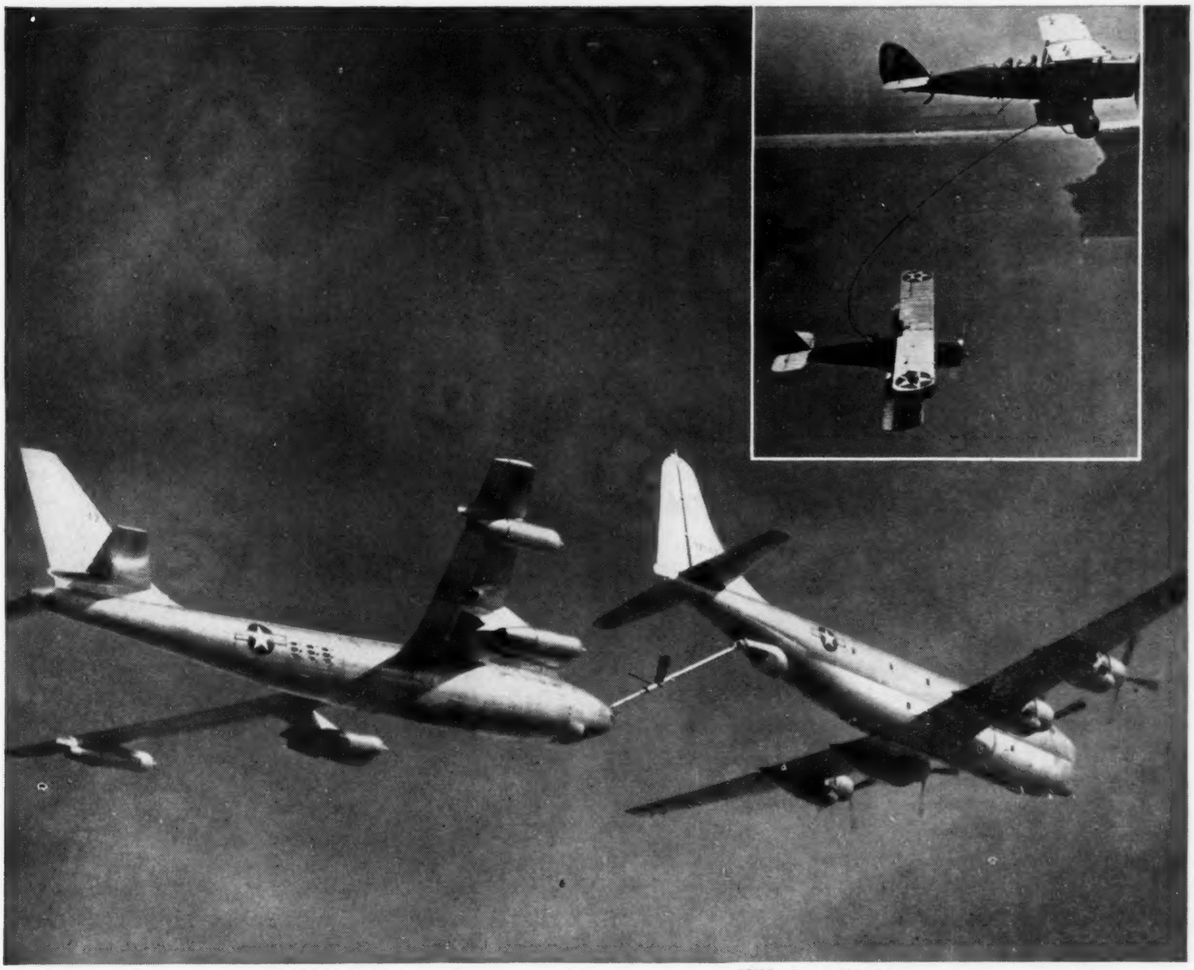
its acceptability can be determined. One such test set is the "Portable Test Set 6030-B"[2], which was designed to perform operating tests on Distributor - Transmitters Types 5031 and 5032 and associated equipment. Another test set, "Rotary Switch Shelf Test Set 5124-A"[3], was designed to trouble shoot and test automatically the operation and wiring of the many rotary switch shelves that are used in all of the reperforator switching centers. Items such as carrier equipment, motors, and rectifiers do not need to meet a time function requirement but must meet certain performance tests which can be determined with electrical measuring instruments and standard test procedures.

Theoretically, an inspector's function is simply to determine if a given product meets the requirements of our specifications. If it does, he applies his approval stamp and goes away. Unfortunately, few inspections of anything but very simple and standard products turn out to be so easy. As errors may be made by even the best workmen, and specifications may not be perfect, a difference in interpretation can result between the producer and the inspector. Conferences must then follow to determine whether the error has made the apparatus entirely unusable, whether it can be corrected, or whether some changes can be made in the specifications that will permit a suitable correction. Operating tests on new equipment may even uncover certain weaknesses in design that will involve changes in material or construction. The Material Inspections Engineer must take a prominent part in all such adjustments, for his paramount duty is to see that the quality of material purchased by Western Union shall be up to the standard required by its specifications.

This description of the operation of the Material Inspections Division refers only to its primary function, that of sorting material to separate good from bad. The Division is in addition, interested in preventing unsatisfactory material from being manufactured, and it therefore steps out of the very narrow confines of

(Continued on page 44)

1923—first aerial refueling

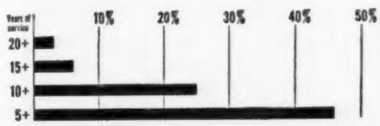


1954—Boeing KC-97 tankers completed 16,000 refuelings last year

30 years of progress in aerial refueling

The small picture shows the first aerial refueling by the Air Force. The large picture shows a Boeing KC-97, today's standard Air Force tanker, transferring 600 gallons of fuel a minute to a Boeing B-47 Stratojet bomber.

Boeing pioneered aerial refueling tankers and equipment. Further, during its 38 years, it has constantly pioneered trend-setting designs in commercial and military aircraft. This has meant such continuous growth that Boeing now employs more engineers than ever before, including the World War II peak. Boeing offers *stable* careers to engineers of virtually EVERY type: civil, mechanical, electrical and aeronautical. The company employs draftsmen and engineering aides for routine work, thus freeing engineers for more creative assignments.



Boeing engineers enjoy long-range careers—46% of them have been at Boeing 5 or more years, 25% have been here 10 years, and 6% for 15 years.

In addition to stability, Boeing offers an unusual variety of research, design and production opportunities, including work with new materials, guided missiles, jet bombers and transports, and research in nuclear-powered aircraft and supersonic flight.

Boeing makes it possible for engineers to take graduate studies while working, and reimburses them for all tuition expenses.

For further Boeing career information, consult your Placement Office, or write:

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Company, Seattle 14, Wash.

BOEING

SEATTLE, WASHINGTON   WICHITA, KANSAS

HYDRAZINE

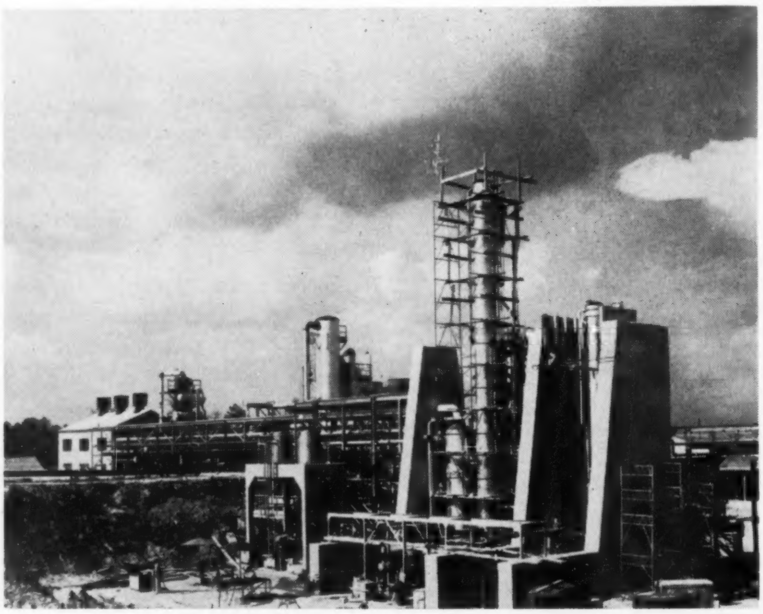
by FELIX J. ROSENGARTEN, ChemE '57

Developed as a rocket fuel, this highly active nitrogen-hydrogen compound is being used in the fields of medicine, agriculture, metallurgy, and textiles.

Until fairly recently very little had been heard of the chemical, hydrazine. Suddenly it was claimed as one of modern science's most fabulous chemicals. Based on ammonia, it is a highly reactive substance which first came into prominence during World War II as one of the chemical fuels used in German rockets. Today, hydrazine is not only used as a fuel but is also found in explosives, plastics, insecticides, dyes, oxidizing and metallizing agents, pharmaceuticals, detergents, soldering fluxes, textiles, chemicals, and, doubtlessly, has many more unpublicized and undiscovered functions.

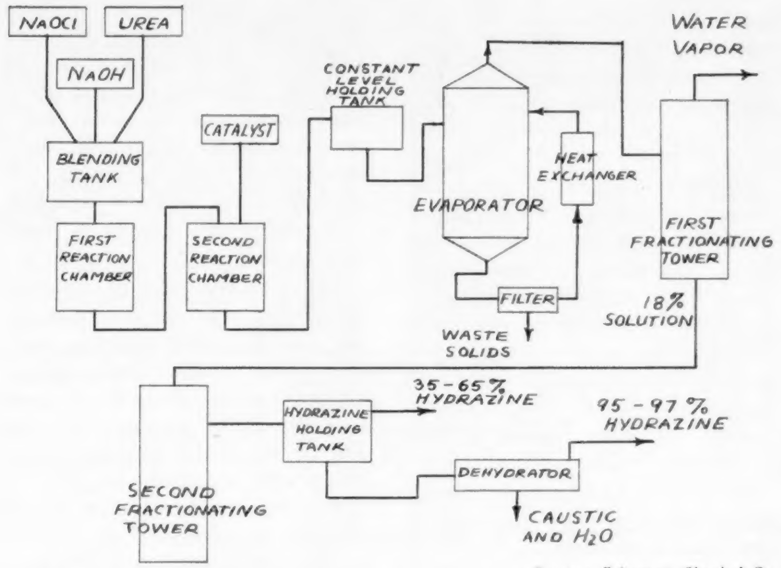
Seventy-nine years ago, when the hydrazo compounds, symmetrically disubstituted hydrazines, had only been known to exist, Emil Fischer, a German organic chemist, reported the preparation of the simple aryl hydrazines and characterized not only free phenyl hydrazine but also the salts of this particular nitrogen base. He suggested the name Hydrazine for the parent substance, N_2H_4, and spoke of its derivatives as the substituted hydrazines. Fischer, Curtius, de Bruyn, and others learned a great deal about the chemical over the turn of the century; Curtius had even isolated the material itself. In 1907, Friedrich Raschig, another German chemist, worked out the method of synthesis that today bears his name: this involved the reaction of ammonia (and/or urea) with sodium hypochlorite. Other methods for the synthesis of hydrazine were narrowed down to: 1) the reduction of compounds containing a nitrogen to nitrogen bond, 2) the decomposition of ammonia, and 3) the oxidation of ammonia by methods other than those involving use of hypochlorite. Photochemical and electric discharge methods, as well as catalytic oxidations over wide pressure and temperature ranges, have been tried, but none have shown any significant advantage, Thus, the Raschig synthesis, or modifications of it, is the only method really being used today on a large commercial basis for the production of hydrazine and its derivatives.

Fig. 1. Olin Mathieson's Hydrazine plant at Lake Charles, Louisiana.
—*Courtesy Olin-Mathieson Corp.*



The Chemical

Anhydrous hydrazine, N_2H_4, is a clear, colorless liquid, highly polar, and completely miscible in water, resembling water with about the same density and a boiling point that is only slightly higher. Unlike



—*Courtesy Fairmount Chemical Co.*

Fig. 2. Urea synthesis of Hydrazine as used by the Fairmount Chemical Company.

water, it will contract upon freezing, eliminating the problem of rupturing containers at subzero temperatures. Hydrazine is classified as corrosive by the Interstate Commerce Commission, yet it does not meet the qualifications of a flammable liquid.

The hydrazine molecule consists of two nitrogen atoms bonded together, with two hydrogen atoms attached to each nitrogen. The hydrogens are readily replaced by other atoms or groups of atoms through a variety of chemical reactions to provide the chemical's extreme wide range of molecular combinations and versatile properties. However, the nitrogen bond is of such a strong linkage that any reaction vigorous enough to break it releases a large amount of chemical energy. Thus, hydrazine with this very powerful and concentrated source of energy is one of the most highly reactive of the inorganic chemicals. This is also the fact that gave rise to its extreme importance in rocket fuels.

Hydrazine and water form an azeotropic mixture which boils at 120.3°C. and which contains 68.5% (by weight) N_2H_4. To concentrate hydrazine beyond this composition, it is necessary to dehydrate chemically or to extract azeotropically. However, the 85% hydrate, or other aqueous solutions, are most often sold commercially, since a composition approaching the azeotrope is usually found adequate.

Hydrazine's lower explosive limit in air is reported to be 4.7% by volume, but, in contrast to other fuels, hydazine has no upper limit to the explosive range. To ensure safe operation, hydrazine is very commonly padded with an inert gas. If nitrogen were present in a closed vessel and an explosion occurs, the pressure is estimated to increase twelve- to fourteen-fold; with air present, even higher pressures are estimated.

Chemically hydrazine is classified as a strong reducing agent and a mild alkaline base. With oxidizing agents it will react readily and exothermically. The temperature, concentration, and prevailing catalytic conditions determine the rate of a reaction.

In the absence of oxidants, hydrazine undergoes decomposition according to the equation,

$$3N_2H_4 \rightarrow N_2 + 4NH_3.$$

The U. S. Bureau of mines has measured minimum ignition temperatures for hydrazine in the presence of various surfaces, and it has found that no ignition occurs up to 415°C. on stainless steel with air absent; with air present the temperature is 160°C. Thus, care must be exercised in the handling and storage of hydazine to prevent contamination or exposure to surfaces which will catalyze decomposition and lead to ignition. Since stainless steel is the most inert substance, it is used a great deal in plants and as container material for shipping purposes.

Hydrazine belongs to the hydronitrogen family, whose common and best known member is ammonia. Many chemists have compared hydrazine to the hydrocarbons with respect to its potential for producing derivatives.

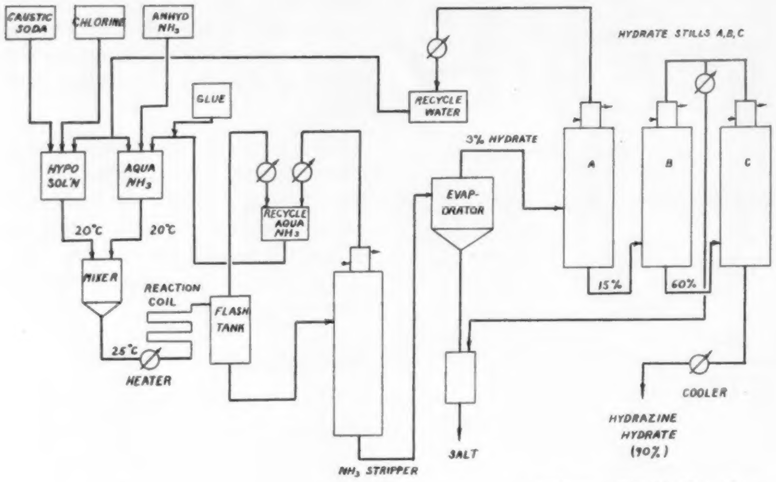
Development

When after the world war Germany's progress in the search for a rocket fuel was revealed, considerable activity and interest started in the United States. The Germans had worked with hydrazine hydrate plus an oxidant such as hydrogen peroxide or liquid oxygen, and they had employed the Raschig process for the first time on a plant scale in two units built at Leverkusen and Gersthofen. Neither of these plants ever reached full production, but the hydrazine-oxidant mixture that was used in the few rocket fighter planes made them capable of climbing at the surprising rate of seven miles a minute. The military services, therefore, immediately classified the new fuel with the rest of their activities on liquid-fuel rockets.

Fairmount Chemical Co., a pioneer in the hydrazine field since 1939, began producing limited quantities of anhydrous hydrazine early in 1946. The Mathieson Chemical Corp. continued with a research program which they had begun in 1939 on the applications of hydrazine, and in 1948 they began the manufacture of the chemical in pilot plant quantities. By 1952, both these companies, the two major producers, were expanding capacity of their production units. In 1953, the country's first major hydrazine plant, built jointly by Mathieson and Olin Industries, Inc., shown in Figure 1, was completed.

Military requirements still take most of the hydrazine output in the United States. It is expected that non-military uses will be developed further in the future and will eventually become significant in terms of total demand.

This increase in production has



—*Courtesy Olin Mathieson Corp.*

Fig. 3 Modified Raschig synthesis of Hydrazine. The flow sheet is for the Gersthofen plant, but Mathieson uses a very similar arrangement.

also had a large effect upon the price of hydrazine. Originally selling at $50 a pound, when the material was being made only in experimental quantities, hydrazine's price was reduced to $9 a pound in the early production years after the war. Today the price tag varies from $2.50 to $1.78 a pound on a hydrazine basis for the hydrate in solution. Officials of both companies believe that this will eventually be brought down to less than 50 cents, as the processes improve in efficiency and economy.

Production

Fairmount's production of hydrazine is based on urea, while Mathieson's depends on the use of ammonia. The latter is the Raschig process[1] which involves the reaction of 15- to 30-mole excess of ammonia (as 28% aqueous solution) with sodium hypochlorite (70 to 100 grams per liter available Cl_2) at 160°C. Glue (0.1%) is present in this system as an inhibitor to prevent excessive decomposition during synthesis. From the dilute (1 to 2% N_2H_4) synthesis liquor, weak hydrazine is recovered by flash evaporation. In the same step, by-product sodium chloride is crystallized and separated by filtration. The dilute hydrazine is then fractionated to obtain the hydrate composition.

Alternately, the hydrazine may be recovered by precipitation from the synthesis liquor as monohydrazine sulfate. The sulfate must be neutralized with excess concentrated caustic soda to release hydrazine hydrate, which can then be distilled off.

The following equations describe the steps in the process:

Synthesis

$$NaOH + Cl_2 \rightarrow NaOCl + NaCl$$
$$NaOCl + NH_3 \rightarrow NH_2Cl + NaOH$$
$$NH_2Cl + NH_3 \rightarrow N_2H_4 + HCl$$

Decomposition

$$2NH_2Cl + N_2H_4 \rightarrow 2NH_4Cl + N_2$$

Recovery

$$N_2H_4{\circ}H_2O + H_2SO_4 \rightarrow N_2H_4{\circ}H_2SO_4$$
$$N_2H_4 \cdot H_2SO_4 + 2NaOH \rightarrow N_2H_4{\circ}H_2O + Na_2SO_4$$

Depending on the concentration of the reactants and the ratio of ammonia to sodium hypochlorite, the over-all yield through the synthesis step, based on chlorine, ranges from 50 to 70%. Within limits, results are improved as the concentration of reactants is reduced and as the ammonia-hypochlorite ratio is increased.

The process[2] employed by Fairmount depends on the following reaction:

$$CO(NH_2)_2 + NaOCl + 2NaOH \rightarrow N_2H_4 + Na_2CO_3 + H_2O + NaCl$$

The starting materials, urea, sodium hydroxide, and sodium hypochlorite, are fed into an agitated, insulated reaction blender, and the process continues as shown in the flow sheet (Figure 2.).

Fairmount encountered a few difficulties during its early runs. They found that siliceous impurities in the caustic soda and raw materials coated the walls of the heat exchanger. This problem was solved by improving raw material quality and by a few design changes. The selection of packing material, which would withstand the severe operating conditions of the evaporator also proved difficult, but metallic packing is now used and repacking is needed weekly instead of every four hours.

The first fractionating tower in the process only yields an eighteen per cent hydrazine solution, while the second column makes a technical grade out of the hydrazine with only traces of ammonia present. For the production of pharmaceuticals grades or anyhdrous hydrazine a final caustic dehydration or distillation is required. This produces a water-white product with a non-volatile content of less than 0.001%.

Of the two methods described, Mathieson finds the Raschig process potentially cheaper, owing largely to lower raw material costs. One of Fairmount's leading cost factors is the price of steam. Mathieson has the advantage of being able to use natural gas, because of its location, while Fairmount must use high-priced oil. However, Fairmount is still capable of producing hydrazine at a cost competitive to that of the Mathieson plant.

Reactions

Upon neutralization, hydrazine, being primarily a diacid base, will form various types of salts, depending upon the acid involved. With hydrochloric acid two salts are produced. $N_2H_4 \cdot HCl$ and $N_2H_4 \cdot 2HCl$; with H_2SO_4 the following are possible: $N_2H_4 : H_2SO_4$, $(N_2H_4) : 2H_2SO_4$, and $N_2H_4 \cdot 2H_2SO_4$. Reactions with organic acids produce similar salts, which, upon heating, will lose water to give hydrazides. The common salts are mostly soluble in water but there are a few exceptions.

Dihydrazine sulfate added to solutions of metallic sulfates causes insoluble double salts to precipitate. Similar double salts based on $N_2H_4 \cdot HCl$ and metal chlorides are also known. The double salts in general are more difficult to prepare, but they are also more soluble in water.

To illustrate typical organic compound reactions, the following show

hydrazine in an alkyl substitution and combining with an aldehyde, a ketone, and an acid respectively:

$N_2H_4 + RX \rightarrow H_2NNHR \text{ (or } H_2NNR_2) + HX$
$2RCHO + N_2H_4 \rightarrow RCH{=}NN{=}CHR$
$R_2CO + N_2H_4 \rightarrow R_2C{=}N\text{-}NH$
$RCOOH + N_2H_4 \rightarrow RCONHNH_2$

Hydrazine will also react with organic esters, anhydrides, amides, and acid chlorides to give hydrazides and hydrazines which may be either cyclic, diacyl, or primary. Hydrazine, being a bifunctional compound, will also occur in more complicated reactions such as condensation with other bifunctional compounds to form crosslinked and linear polymers.

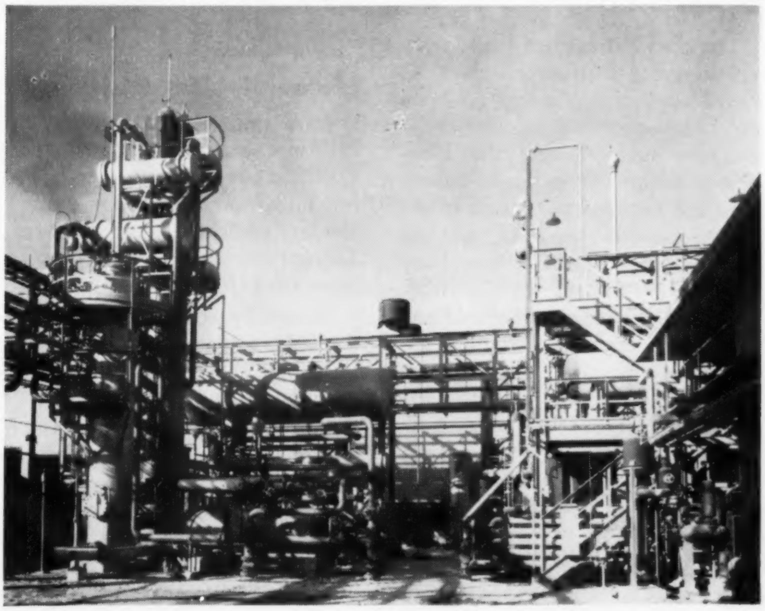
Uses

With such a wide range of properties and reactions, one would also expect a great variety of uses. Rocket fuels may have brought hydrazine out of obscurity, but its future today appears to lie in its chemical reactivity. Already over 2000 derivatives have been reported, many with new and unusual properties. These include numerous straight chain, cyclic and cross-linked molecules, as well as a number of complex nitrogen-containing compounds useful in the preperation of dyes and pharmaceuticals. Simpler hydrazine derivatives, such as substituted hydrazines, hydrazones, hydrazids, and semicarbizides, are being used as insecticides, fungicides, antioxidants, textile processing agents, and in explosives and photographic developers.

In the drug field, hydrazine derivatives have shown promise in the treatment of such varied diseases as tuberculosis, high blood pressure, and urinary tract infections. Hydrazine is also being employed in the preparation of hormones, antihistamines, antibiotics, and certain vitamins and sulfa drugs. One member of a group of drugs based on the nitrofuran nucleus, derived from hydrazine and furfural, is being used in poultry feeds to prevent the deadly coccidiosis disease.

Some of the most interesing uses of hydrazine derivatives are in agriculture. Maleic hydrazide, has shown startling properties as a growth retardant for grass and other plants. Tested for several seasons on grass plots along state highways in New York and Connecticut, the matterial, known as MH-40, has reduced the number of mowings required from 19 to 2 per season. Over fourteen states are now using it to save mowing costs. The hydrazide can be applied in solution as a spray to stop vegetables, such as potatoes, onions, or carrots, from sprouting during storage. It is being used to prevent the opening of buds on fruit trees until the danger of frost is past, to produce male sterility in hybrid corn, and to prevent the flowering of tobacco.

Fig. 4. View of synthesis section, including distillation and recovery, with the ammonia compressor building in the background. The ammonia distillation unit is at the left. Part of Olin Mathieson's Hydrazine plant. —*Courtesy Olin Mathieson Corp.*



Other derivatives of hydrazine are serving successfully as insecticides and fungicides. One has even been found which for the first time will kill mites without poisoning the birds that feed on the dead mites.

New nitrogen-ring dyes, synthetic detergents, wrinkle-resistant coating for textiles may be made from hydrazine derivatives. Derivatives may come to serve as modifiers of synthetic fibers and plastics, particularly those of the polyamide type, such as nylon and Dacron. Evidence exists that hydrazine-modified fibers permit finer fibers with greater elasticity and strength.

Hydrazine's property of being a strong reducing or de-oxidizing agent is used in the separation of rare metals from their oxides or salts, in the plating of thin coatings of metals on glass, plastics, and other non-conducting materials, and in removing final traces of dissolved oxygen from boiler water which otherwise would cause corrosion problems.

The reducing action is also put to work in the form of hydrazine hydrobromide as a soldering flux for copper and brass. This flux permits formation of a good soldering bond but leaves no corrosive residue on the metal. At present, hydrazine flux is being used widely in the soldering of automobile radiators. Superior fluxes have also been developed for the difficult problem of soldering aluminum and have proved very effective.

Still another important use is as a foaming agent in the manufacture of foam rubber. Hydrazine agents break down into inert gases which are odorless, will not burn, and will not deteriorate the rubber.

Hydrazine's future, therefore, is certainly assured. Undoubtedly, new developments will lead to new fields of even broader industrial potential.

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AT YOUR SERVICE

One hundred college seniors are sharing this year in $50,000 worth of General Electric Company scholarships. This is the second consecutive year the company has granted 100 scholarships of $500 each to outstanding college students to assist them to complete their senior years.

Sixty-nine of the scholarship winners were selected from all sections of the country by the General Electric Professors' Conference Association, a group of college engineering professors who have participated in summer programs conducted by G.E. over more than three decades.

The association, representing more than 100 colleges and universities throughout the United States, is divided into 14 geographical divisions, each of which pass upon applications for the technical scholarships and select the winners.

Other committees of educators will co-operate with college administrators in selecting the recipients of the 31 other scholarships.

Nineteen of the scholarships were awarded to juniors studying business administration; 15 to those interested in various phases of manufacturing; 9 to those studying marketing; three in the employee and public relations fields, the other 54 scholarships going to engineering students.

Awarding of the 100 scholarships for the 1954-1955 school year is part of the General Electric Company's multi-million dollar program to encourage interest in education and to help encourage students to prepare themselves for the better jobs in the industry.

Power Specialists

The Corps of Engineers' Research and Development Laboratories, located 20 miles south of Washington, D. C. at Fort Belvoir, Virginia, need several specialists in the field of electric power generation to carry on their program of developing improved equipment for the Armed Forces.

With electric power so vital to the operation of modern weapons, the defense contribution of work in this field cannot be overemphasized. The openings offer opportunities in the field of design engineering, application engineering and laboratory test work in association with top flight personnel in one of the country's best-equipped laboratories.

Applicants must hold a degree in electrical engineering or have considerable practical experience in their field. Salaries range from $3410 to $7040 commensurate with experience. Those interested should apply to Mr. Walter H. Spinks, Chief, Administration Department, ERDL, Fort Belvoir, Virginia.

Librarians Needed

The United States Civil Service Commission announces that there is still a need for librarians in various Federal agencies in Washington, D.C., and vicinity for positions paying entrance salaries of $3,410 a year.

Applicants are required to take a written test and must have completed a full 4-year college course or the equivalent experience in library work.

NSF Fellowship

The National Science Foundation has announced that it plans to award approximately 700 graduate and 130 postdoctoral fellowships for scientific study during the 1955-1956 academic year. These fellowships are awarded to citizens of the United States who are selected solely on the basis of ability. They are offered in the mathemtical, physical, medical, biological and engineering sciences, including anthropology, psychology (excluding clinical psychology), geography and certain interdisciplinary fields.

Graduate fellowships are available to those who are studying for either masters' or doctoral degrees at the first year, intermediate or terminal year levels. College seniors who expect to receive a baccalaureate degree during the 1954-1955 academic year are eligible to apply. The postdoctoral category includes awards to individuals who, as of the beginning of their fellowships, have earned a doctoral degree in science or have had research training and experience equivalent to that represented by such a degree.

All applicants for graduate (predoctoral) awards will be required to take an examination designed to test scientific aptitude and achievement, which will be administered on January 27, 1955. Selection of Fellows will be based on examination scores, academic records and recommendations regarding each candidate's abilities. Evaluation of each candidate's qualifications will be made by panels of scientists chosen by the National Research Council of the National Academy of Sciences. Final selection of Fellows will be made by the National Science Foundation. Fellowship awards will be announced on March 15, 1955.

The annual stipends for graduate Fellows are $1400 for the first year, $1600 for the intermediate year, and $1800 for the terminal year. The annual stipend for postdoctoral Fellows is $3400. Dependency allowances will be made to married Fellows. Tuition and laboratory fees and limited travel allowances will also be provided.

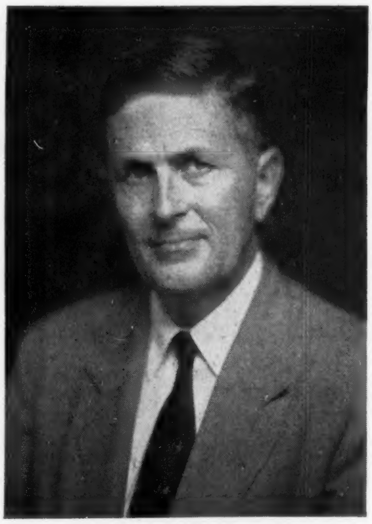
Meteorological Positions

An examination for Meteorological Aid has also been announced by the U.S. Civil Service Commission for filling positions principally in the United States Weather Bureau, Department of Commerce. The salaries are $2,950 to $3,410 a year.

To qualify, competitors must pass a written test and, in addition, must have had appropriate education or experience.

Full information regarding the requirements for either position and instructions on applying may be obtained at many post offices throughout the country and from the U.S. Civil Service Commission, Washington 25, D.C.

CORNELL SOCIETY OF ENGINEERS



Walter M. Bacon

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates, and former students and to establish closer relationship between the college and the alumni."

SECURITY AND OPPORTUNITY

Almost everyone is interested in security for themselves and their families. There is no doubt that it is important. Its importance can however be over emphasized. Security gained without involving any risk or without hard work on the part of most of the people who wish to enjoy it is not real security. It isn't real because it cannot last.

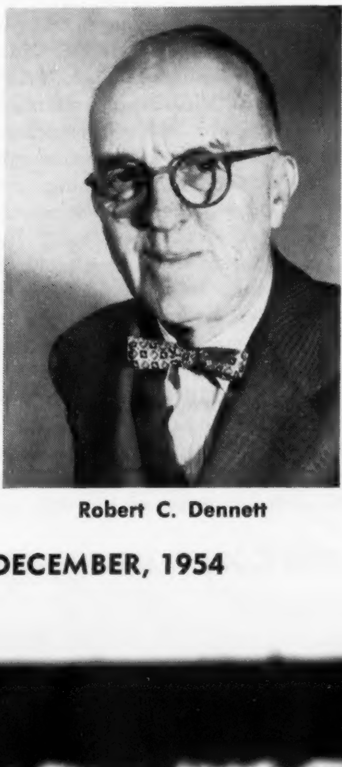
By security most people apparently mean financial stability and success to the point that their families are well housed, well fed, well clothed and their children well educated. They want to be able to meet those family emergencies such as serious illness that almost inevitably arise. They want a comfortable and independent old age, free from financial difficulties, as well as from the feeling that they are a burden on their children, friends, or charity. As individuals people can work for these desirable goals but individual security cannot be attained unless the nation itself is secure. National security not only means the strength to ward off or deter attack by others but also requires a basically sound economy. This sound economy depends on the continued growth of industry and the development of new and improved products for both defense and peace time use. This growth and improvement under our system of government cannot take place without some risk. There is, of course, the risk taken by those providing the necessary capital for new or expanded enterprises. Without the willingness of investors to assume some risk industrial growth cannot take place. There is also the need for individuals to take jobs with these new enterprises and to grow with them. This involves a job risk but at the same time provides an opportunity for greater than average success and in the long run better security. Most people at some time either at the start of or during their business careers have been presented with this type of opportunity and have been faced with the problem of choosing between the comparative safety of immediate or existing job security and possible greater future success and security involving some risk. So many people in looking back over their careers have seen where those who took opportunities refused by them have succeeded and are at the present time more successful and more secure. Care must be taken of course that the risks involved are not too great but in the long run those who take advantage of opportunity and accept the risks will be the ones who gain success and who are most secure. These people will not only be more secure as individuals but will at the same time have contributed more to the national security.

ALUMNI ENGINEERS

George Whitfield, M.E. '96, rode his bicycle one-hundred miles from Washington, D.C. to the University of Richmond in Richmond, Va. Last year he pedaled from Washington to Lawrence, Kans., and back, a journey of 1600 miles. His address is Aberdeen Hall, 3415 Thirty-eighth Street, NW, Washington 16, D.C.

Ed V. Berg, M.E. '02, has retired as supervisor of dikes on the Lower Columbia River and has been appointed county civil defense director. His address is 1303 Eighteenth, Longview, Wash.

Robert C. Dennett, C.E. '04, was recently honored for fifty years of service with the National Board of Fire Underwriters. Dennett started with the board as a field engineer and later advanced to office engineer and assistant chief engineer. Early in his career he surveyed the water systems of 150 major cities. During World Wars I and II he worked with the government on Naval fire protection. Among the organizations of which Dennett is a member are the American Society of Civil Engineering and the Cornell Society of Engineers.



Robert C. Dennett

Nathan N. Tiffany III, C.E. '05, sends word of three generations of Cornellians. He writes that he is president and treasurer of Southhampton Lumber Corp., East Hampton; **Nathan N. Tiffany IV '32** is with Tilo Corp., Plainfield, N. J.; and **Nathan N. Tiffany V '56** is in the Army.

J. Wright Taussig, C.E. '08, senior vice-president of Raymond Concrete Pile Co., New York City, retired on June 30. He joined the company in 1908, and had been an officer and director for more thar thirty-five years. He will remain a director. Taussig is the father of **Frederick F. Taussig '44** and **Peter T. Taussig '50,** and now resides at Dwight Place & Linden Avenue, Englewood, N. J.

Albert E. Frosch, C.E. '09, '10, is the principal civilian assistant to the Commanding General of the Ordance Ammunition Command,, Joliet Arsenal, Joliet, Ill. Frosch lives in Joliet at 155 North Raynor Avenue.

Robert H. Weir, C.E. '19, the key man in assisting seven governors shape Connecticut fiscal politics over the last 15 years, retired Sept. 1 from the post of State Budget Director. In 1922 he became an engineer for the State Highway Department. From there his broad background and engineering training pushed him to the head of the highway's new budget division. Weir found the two fields (engineering and budget work) not at all different; "In both cases, you're striving for the most efficient and economical way."

Weir is a highly respected man in governmental circles. He now plans to become a private fiscal consultant to municipal and state governments.

C. M. Chuckrow, C.E. '11, has for many years been in the building industry. He put up Knickerbocker Village, the first big slum clearance housing development in N.Y.C., of which there are now thousands, and the very complicated Chrysler building.

George Bain Cummings, B.Arch. '12, 79 Front Street, Binghamton, was re-elected secretary of the American Institute of Architects for a one-year term, June 19.

Nathan W. Dougherty, who originally received the Bachelor's Degree in civil engineering at Tennessee in 1909 and who came to Cornell to receive his Master's Degree in 1913, is now vice-president of the National Society of Professional Engineers, and is its special representative on the advisory committee, National Bureau of Engineering Registration. Nathan is dean of engineering at University of Tennessee; is a member of the Tennessee State Board of Architectural and Engineering Examiners; and is the author of many technical, educational and professional publications. He is married to the former **Agnes Monetith, M.A. '14.**

Francis W. Maxstedt, E.E. '16, 600 Ramona Avenue, Sierra Madre, Cal., is registrar and associate professor of electrical engineering at California Institute of Technology.

Jorge Silva, M.E. '18, (above), signs his oath of office at ceremon-

Jorge Silva

ies appointing him Minister of Economy of the Republic of Chile, June 5. At the time of his appointment, Silva was president of the Cámara Central de Comercio de Chile, an organization composed of all the Chambers of Commerce in Chile.He is also director of Compañia Chilena de Electricidad, an Electric Bond & Share subsidiary operating in Chile.

President of the S. G. Taylor Chain Co. is **E. Winthrop Taylor, E.E. '19,** P.O. Box 509, Hammond, Ind. He has 5 grandchildren and is busy on many matters, including chairing the local chapter of the American Society for Metals and work with the American Welding Society, Society for the Advancement of Management, and civic organizations.

Colonel Raymond O. Ford, M.E. '23, was married July 1 to Lily Wolmers of New York City. **Colonel Ford** is with Bell Telephone Laboratories, Murray Hill, N. J., and is commanding officer of the 307th Ordance Group, US Army Reserve. In 1940-41, he was assistant professor of Military Science & Tactics at the University. The Fords reside at 206 Milburn Avenue, Millburn, N. J.

Morris Shapiro, M.E. '24, has moved to a new address in Washington, D.C.: 3900 Sixteenth Street, NW, Washington 11.

James A. Rowan, M.E. '24, was from 1944-51 assistant to the president of Great Lakes Steel Corp., Detroit, Mich. Since 1952, he has been chairman of the Group Attitudes Corp., 500 Fifth Avenue, New York. Rowan lives in Princeton, N. J., and has five children, one of whom, **Keith,** is in the Class of **'56** at Cornell. Another son, Douglas, is in the same class at Lawrenceville. Rowan is a member of the Cornell Clubs of Michigan, Trenton, and New York.

Frank W. Miller, M.E. '24, is vice-president in charge of manufacturing and a director of Yarnall-Waring Co., Philadelphia, Pa. **Miller** is president of the Engineers Club of Philadelphia. A son and daughter,**Rolney** and **Clarice,** attended Cornell and a daughter, Joyce, graduated from Hood College in Maryland. His home address is 7505 Cobden Road, Philadelphia 18.

George A. Rauh, M.E. '24, who lives at 1007 Central Avenue, Union City, N. J., is division plant superintendent for New York Telephone Co., with offices on West 50th Street, New York. George married **Ysabel A. Muller '25,** and they have five sons, **George A., Jr. '55, Robert A. '57,** James A., William A., and Alan.

Laurence G. White, E.E. '28, who heads the sales engineering firm of L. G. White & Co., Silver Spring, Md., has opened his second branch office in Winston-Salem, N. C. In charge of it is **Silas T. Wild '29.**

Dexter S. Kimball, Jr., M.E. '28, has been elected as an alumni trustee of Cornell. Kimball is vice-president, general manager and a director of Bendix-Westinghouse Air Brakes Co., Elyria, Ohio. He taught Industrial Engineering at the University from 1931-34. Co-author with his father of "Principles of Industrial Organization", he has written texts for International Correspondence School and developed industrial training programs during the war. He resides in Elyria.

Dexter S. Kimball, Jr.

In a letter to Professor N. A. Christensen, Civil Engineering, Colonel **Robert K. McDonough, C.E. '29,** sends word of other engineers, both in and out of the Army, from Classes **'27, '28,** and **'29.** He says: "I am presently Engineer, Eighth Army, in Korea. My two immediate predecessors in the job were Brig. Gens. **Howard Ker '27** and

William C. Baker '28, both now in the Office, Chief of Engrs. Of my own group in '29, **Elvin R. Heiberg** is head of the Dept. of Mechanics at West Point, two—**Walter W. Hodge** and **Joseph W. Cox**—are dead, **Max S. Johnson** (Brig. Gen.) is now assistant commandant of the Army Engineer School, Ft. Belvoir, Va. **Herman W. Schull** is US District Engineer, Jacksonville, Fla. **Keith R. Barney** is in the Office, Chief of Engineers, **Frank X. Purcell** is with the Air Force, and **Charles H. Mason** is retired. **Walter Knox** (not Army) **'29** is resident engineer, Jim Woodruff Dam, Chattachooche, Ga., under the Mobile District Corps of Engrs., USA. The acting Commanding General, Eighth Army (combat forces) in Korea is Lieutenant General **Bruce C. Clarke '27**, who was in the Corps of Engineers. Colonel McDanough's address is Engr. Sect., Hq., 8th Army, APO #301, c/o PM, San Francisco, Cal.

James T. Veeder '42, has been appointed the first full-time Extension television specialist at the University. He will help county Extension agents and Cornell specialists present daily and weekly programs, conduct television workshops, and assist in preparing TV films. For the last twelve years, Veeder has been 4-H Club agent in Cattaraugus County.

George B. Marchev, M.E. '43, 45 Colflax Road, Springfield, N. J. is vice-president and sales manager of Gordon Corp.

Herbert H. Davis, Jr., C.E. '48, is an investment banker with Kirkpatrick-Pettis Co. in Omaha, Neb., where he lives at 6153 Walnut Street.

Herbert M. Canter, E.E. '47, 215 Crawford Avenue, Syracuse 3, has been elected notes editor for the Syracuse Law Review for this year. He will graduate from Syracuse University college of law in June, 1955.

Thomas M. Potts, M.E. '49, has been transferred from Baltimore, Md. to North Andover, Mass., where he is an industrial salesman with the New England division of Esso Standard Oil Co. Potts lives at 330-A Andover Street in North Andover.

Quentin H. Davison, M.E. '49, 19 Fairview Avenue, Glen Rock, N. J., is advertising and production manager of Davison Publishing Co., Ridgewood, N. J. The company specializes in publishing textile trade annual directories.

Richard Montgomery, Ch.E. '51, is now a junior engineer with Socony Vacuum. He's living at 77 Fairview Drive, Short Hills, N. J.

Harry Henriques, Ch.E. '51, married the former Emily Watson. He is with Bakelite Co. He lives at 619 Greenbank Road, North Plainfield, N. J.

David J. Hower, C.E. '52, has been appointed a standards engineer at Sharp and Dohme, division of Merck and Co., Inc. He was discharged from the service in May following a two year tour of duty as first lieutenant with the U.S. Army Ordinance Corps.

BRAIN TEASERS

As a regular monthly feature, the Editors of the CORNELL ENGINEER last year presented a column of "brain teasers" to challenge reader ingenuity. While the problems in the series may have stimulated confusion among the brave intellects attempting their solution, they caused a similiar, less desirable effect among staff members who were responsible for obtaining the correct answers and giving the rightful winners due credit.

Because the puzzles had not only a teasing effect, but a twisting one as well, the ENGINEER wants to set the record straight before starting another precarious adventure in trying to confound its readers. The solutions to several of last year's problems have not been previously revealed because no one in the ENGINEER Office could determine what the answers were. Rather than ruin any more good friendships, frighten away enthusiastic compets, and run over printing deadlines, the editors will close the matter of last year's Brain Teasers by recording the solution to several of the most elusive enigmas. They will then start anew with clear determination to never again allow brain teasers to get the better of them. It will be a tough struggle, but the editors are confident that they will stand firm against the hypnotic effects of the ages of monkeys and their uncles, straight flushes with deuces wild, orange segments, ferry boats, and athletic insects.

The October 1953 issue posed the problem of the value of the square root of two raised successively to the square root of two power an infinite number of times. The answer, once and for all is 2.

From the same issue, the solution to the problem of the monkey and his uncle who are in the frustating positions of hanging from opposite ends of a rope over a pulley. The monkey is a year and six months old, the rope is five feet long. Cor-

rect solutions for the November problems are: No. 1: 3 children. No. 2: 5-5/12 inches. No. 3: .732.

Readers submitting solutions to the ENGINEER were in general agreement that the answers to questions 2 and 3 of the January, 1954 Brain Teasers are respectively, 393.75, and 338, 350. The orange slicing problem caused more difficulty. Though the challenge of cutting an orange into the largest number of slices by using only four strokes may have practical value to fraternity stewards, the purely academic connotations of the problem lead engineers to belive that the correct answer is 15.

The particular width of the Hudson River at the point of the race between two nimble, instantaneously reversing ferry boats as described in the February column, is 3000 yards. The insect in the first problem can travel a height equal to 42/1000ths of the radius of the bowl. (This is on a full stomach.) In March, readers were in unanimous agreement that the answer to problem 2 involving an addition in which letters had been substituted for numbers is $10,652. The length of time required for the homing torpedo in problem 1 to reach its target is $r/Ca^2+b^2)^{1/2}$. Most readers determined that the next number in the series presented in the third problem is 87. The May issue posed a problem of a rod standing on a frictionless surface supported on its left by a block. If the rod were struck as shown, the motion would be such that the rod would move to the right according to $F=Ma$ and rotate clockwise so as to satisfy angular momentum considerations. Whether or not the lower end of the rod touches the block will depend on the mass of the rod and the magnitude of the applied impulse.

Rather than add to the confusion, last year's monthly three dollar prizes for the winners will not be awarded except for those sent out before summer vacation. This year, Brain Teasers will once again appear on the pages of the CORNELL ENGINEER. But they will be controlled with a firm hand and never again allowed to wander from the straight and narrow path of single, determinant answers.

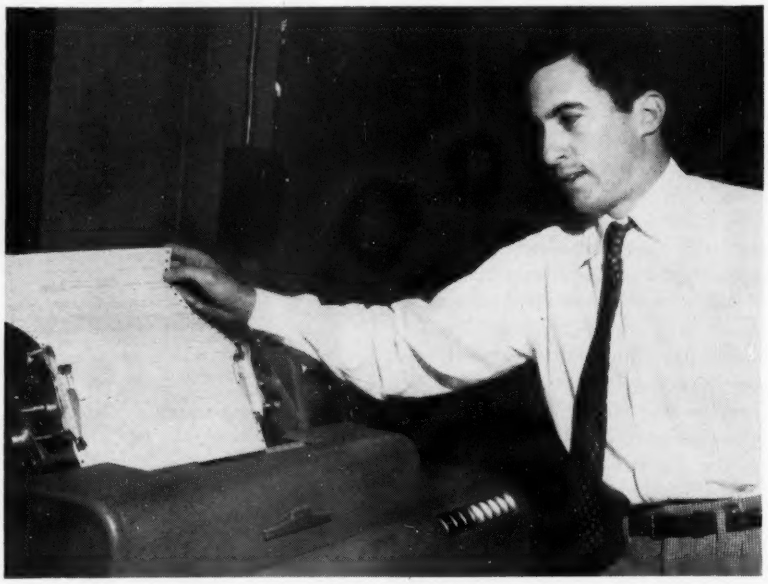
College News

The Cornell Computing Center, now completing its first year of operation, has effectively filled its dual role of educational instruction and practical application in the computer field. The Center, originated last Jan. 1, is administered by the mathematics department with an advisory committee of faculty members from such departments as engineering, physics, sociology, statistics, and agriculture.

The purpose of the Cornell Computing Center includes training qualified people in the techniques of computer programming. The Center's planners hope that advanced degrees will eventually be offered in applied mathematics, with emphasis on numerical analysis and machine computation. A second major function of the center is that of project computing. The Cornell Computing Center has done work for a number of University departments, including calculations in nuclear physics, chemistry, heat power, and mathematics. An indication of the diversified use of the Center's equipment is reflected in the fact that work has also been done in fields of child development, vegetable crops, plant breeding, and agronomy.

Outside agencies have also used the facilities of the Cornell Computing Center. For example, programs have been conducted for the University of Rochester's Institute of Optics and for General Electric's Advanced Electronics Center. The equipment is also available without cost to students who wish to do non-sponsored research. Students do the major part of programming and operating themselves. Sponsored research projects are charged at a rate of 25 dollars an hour to use the entire facilities of the Center.

The Computing Center's calculator, located on the third floor of Rand Hall, is a medium-speed general purpose digital computer manufactured by International Busines Machines Corporation. The device is card-programmed, and can process 150 cards a minute while per-



Mr. Richard C. Lesser, director of the Cornell Computing Center, examines the results from the Center's digital computer.

forming 9000 operations an hour. The Card Program Calculator (CPC) consists of four basic components, cable-connected to form the entire operating unit. The card-reading and tabulating units acts as an input-output mechanism. Punched cards fed in as instructions result in calling forth from storage the desired numbers, performing necessary operations on those numbers, and recording the result in either stored, punched, or printed form. This component also houses eight storage units.

The second major section of the calculator is the actual calculating unit. This unit performs the desired operations on numbers called into it from other parts of the computer. It can do arithmetical problems, including trigonometric functions and logarithms. In addition the calculator can be programmed to do numerical integration and differentiation, matrix multiplication and inversion, simultaneous equations, formula evaluation, and special function computation.

The punch unit forms a permanent record of a given calculation. It presents the result in standard punched-card form. A memory, or auxiliary storage unit, completes the calculator sequence. Information in the unit is not destroyed when it is called out for a calculation. When new data is fed in however, the old stored quantities are eliminated.

The Cornell Computing Center has a variety of auxiliary equipment available to facilitate rapid programming. There is a key punch to transcribe original data on cards, a sorter to order the cards or to select specifically punched cards, a reproducer to reproduce a number of decks of program cards from a single set, and a collator to check the sequence of cards or make insertions or exchanges in card groups.

Richard C. Lesser, director of the Computing Center, reveals that a more powerful calculating machine is on order. The new machine, costing twice as much as the present card program calculator, will be an IBM type-650 magnetic-drum calculator. The machine should be available about a year from next June. Its major advantages over the present computer will include independence from limitations of the speed of cards moving through

the machine and expansion of storage space. It is estimated that the new calculator will be able to complete in a month work that would require several years on the present model. The new machine will be able to handle more involved problems, as the Cornell Computing Center expands its programs in education and research.

Titanium—Wonder Metal?

Despite the claims of early proponents, titanium is not a wonder metal destined to replace all other materials, the head of the Metallurgy Section of the Cornell Aeronautical Laboratory, Inc., recently reported.

Loren W. Smith, writing in *Research Trends,* a quarterly publication of the Laboratory, did say, however, that titanium does possess a number of attractive physical and mechanical properties important enough to justify a highly intensive research effort.

Noting that titanium ore is abundant throughout the world, Smith said the major problems are involved in its extraction. The current price for mill shapes of titanium, such as round and flat bars, is $10 to $15 a pound while sheet stock is selling from $20 to $25 a pound. These figures are comparable with less than $1 a pound for mill shapes or sheet stock in steel and aluminum.

Smith reported that a paradoxical supply problem has now emerged to complicate the titanium problem. A year ago there was a shortage of titanium. Today the consumption of titanium is lagging seriously behind production. The United States at present appears to be the sole producer of titanium. There is no word on titanium from behind the Iron Curtain.

Given time, Smith continued, titanium will find widespread application in the aircraft industry since it has demonstrated qualities superior in many ways to aluminum and steel. Airframe and jet engine manufacturers are now using titanium on a modest scale.

"It must be remembered that the titanium industry is young," Smith concluded, "and that despite broad increases in knowledge, the time has been too short to solve all the formidable problems involved."

Operations Research Symposium Held Here

Twenty leading persons who practice operations research methods in science, industry, and government or who teach in this field were invited to a two-day symposium held at Cornell October 14-15. Under the topic "Education for Operations Research," the group discussed the problem that educational institutions face in training students for careers in this field.

Out of the success of operations research techniques during World War II, applied to problems of military strategy and tactics, has developed widespread interest and research on using the same methods in industrial operations and other government operations. Much of this research involves a close integration between specialists in mathematics, psychology, engineering, economics, sociology and others, while other applications have been made by individuals. The members of the symposium discussed the criteria for training an individual for a career in this field. It was sponsored by the Department of Industrial and Engineering Administration in Cornell's Sibley School of Mechanical Engineering, in cooperation with the education committee of the Operations Research Society of America.

Engineering Educators Meet at Cornell

Nearly 200 members of the American Society for Engineering Education attended the annual meeting of the Society's Upper New York Section at Cornell October 22 and 23. Running from Friday noon to Saturday noon, the program included four technical sessions on a variety of subjects, a dinner, and a general meeting. The section includes all of the state except the metropolitan area. Members were present from Alfred, Buffalo, Clarkson, Rensselaer, Rochester, Toronto, Union College, The State University, and technical institutes and industries.

Principal speakers were Dr. S. C. Hollister, a former ASEE president and dean of the College of Engineering at Cornell, B. R. Teare, Jr., vice president of the Society and dean of engineering and science at Carnegie Tech, and Edward Keonjian, electronics engineer at General Electric. The latter was born in the U.S.S.R. and was an engineer there from 1932 until World War II, during which he was captured by the Germans at the seige of Leningrad and deported to Germany.

Don Secor and Doug Merkle, captains of winning teams in Civil Engineering highway design contest.

He refused to return to Russia after the war and came to this country in 1947. His topic was engineering behind the Iron Curtain and in the U.S.S.R.

Cornellians Reap Awards

Three Cornell students gained recognition in the seventh annual Engineering Undergraduate Award and Scholarship Program, sponsored by the James F. Lincoln Arc Welding Foundation. In the structural award category, Martin Rosenzweig and Theodore Chernak, both Seniors in the School of Civil Engineering, won fourth prize of $75 for their essay, "Design of A Welded Arch Foot-Bridge". Milton Cherkasky, Senior in the School of Mechanical Engineering, won sixth prize of $25 for his essay, "Welded Hydraulic Jack."

Monsanto Chemical Company Scholarships of $700 each have been awarded to two Cornell students: Martin Sage, senior in the College of Arts and Sciences, and James A. Wilson, a fifth-year student in the School of Chemical Engineering. The scholarships go annually to seniors majoring in chemistry or in chemical or mechanical engineering. The recipients are selected for their scholastic achievement personal qualifications, interest in chemistry and promise of future success.

Cornell's RCA Fellowship of $2700 for graduate study in engineering physics has been awarded to Ralph R. Stevens, Jr., who received a Bachelor of E.P. degree at the university last June and who is now in the Graduate School. The fellowship, established at Cornell in 1949, is part of a nation-wide program sponsored by RCA.

Students will help award a new engineering scholarship created at Cornell by the Scott Paper Company of Chester, Pa. The $1000 grant to the outstanding senior in the mechanical engineering course will be decided by a board composed of three engineering students and four faculty members. It is the first Cornell scholarship on which students have a formal vote. Student places on the board will be held by the presidents of Tau Beta Pi and Pi Tau Sigma honorary engineering societies, and the president of the student branch of the American Society of Mechanical Engineers.

And More Awards

Four engineering students at Cornell have been awarded the university's second annual Silent Hoist and Crane Company Materials Handling Prizes.

Arthur S. Liebeskind, ME '55, was awarded first prize of $125 for his essay, "The Porta-Floor Loading System." Second prize of $75 was awarded Mark L. Myers, ME '54, for his essay, "Corrugated Containers for the Handling of Liquids."

Sachiyuki Masumoto, ChE '54, and Morton Lowenthal, ChE '54, received a third prize of $50, offered for the first time this year. They wrote a joint essay on "Transportation in the Chemical Industry."

Stuart Robert Pottasch, a senior in the Department of Engineering Physics at Cornell University, has been awarded a Fulbright Scholarship to study radio astronomy at the State University of Leiden in the Netherlands.

Pottasch is a graduate of Brooklyn Technical High School. At Cornell he has been editor of the Desk Book, president of Independent Council, and president of the Northeast Region of the National Independent Students' Association.

Prof. Winter, Et Al, Prepare Text

Heads of structural engineering instruction in Cornell's School of Civil Engineering have been authors or revisers of the textbook on "Design of Concrete Structure" for the past 30 years.

A fifth revised edition, published in June by the McGraw Hill Book Company, was prepared by Prof. George Winter, present head of the department, and Leonard Church Urquhart, professor in charge of structural engineering before World War II.

The book was first written by Urquhart, who is now a member of Porter, Urquhart and Bevin, consulting engineers in Newark, N. J., and Prof. C. E. O'Rourke, who headed the department until his death in 1947.

Two of the 12 sections in the new edition were revised by Prof. William McGuire of the department. In addition to many changes and expansions in the text, the new edition has an added section on plastic (ultimate) design and prestressed concrete.

CE's Plan Highway

A stretch of highway designed in a contest among Cornell civil engineering students may actually be constructed. It is a cutoff between McEntyre Road in Schuyler County and Black Oak Corners in Tompkins County. The new route would be about a mile long and would save two miles of travel on the current route through Mecklenburg.

The contest was part of the program of Cornell's Summer Survey Camp, sponsored by the School of Civil Engineering at Camp Cornell on Lake Cayuga. The proposals of various teams were judged on Monday September 13 by state highway engineers and road supervisors in Tompkins county. Team A, which won first place for engineering, included Donald Secor, captain, Ronald Katims, Walter Lathrop, Leonard Pisnoy, Louis Schickel, and William Schneidau. Team C, which won first prize for presentation, included Douglas Merkle, captain, Richard Bump, Howard Emery, Donald Graves, Roger Judd, and Michael Nadler.

Each team operated like a group of professional engineers and presented its proposal to the judges just as if it were being presented to a group of officials. Aerial photographs of the terrain, surveying and actual plotting of the highway were part of the contest.

William R. Parlett, Cornell '48, Sets Sights on Executive Sales Job

BILL PARLETT has learned that helpful engineering suggestions promote good customer relations.

"Within the next ten years", says William R. Parlett, young Worthington Sales Engineer, "many of the officers of the corporation, district office sales managers and top salesmen will be retired.

"Appreciating the fact that someone must fill these jobs, our management is striving to develop capable leadership among the younger men of the corporation.

"As a prospective Worthington Sales Engineer, I received several months of classroom instruction by works managers, top sales personnel and application engineers at all of the Worthington plants. The background I obtained was a sound basis for further development and learning gained in one of the product sales divisions and then in a district sales office. After obtaining sufficient product knowledge and sales training, I was ready to sell directly to industry. As more important sales assignments are available, I feel I will progress in proportion to my own development and sales performance.

"As a Worthington salesman I contact a class of trade with which it is a pleasure to do business. The company's reputation is a key to a welcome reception by my customers.

"I have found that with Worthington you have job satisfaction, adequate compensation, and unlimited opportunity."

When you're thinking of a good job, think *high*—think *Worthington.* 3.6

FOR ADDITIONAL INFORMATION, see your College Placement Bureau or write to the Personnel and Training Department, Worthington Corporation, Harrison, N. J.

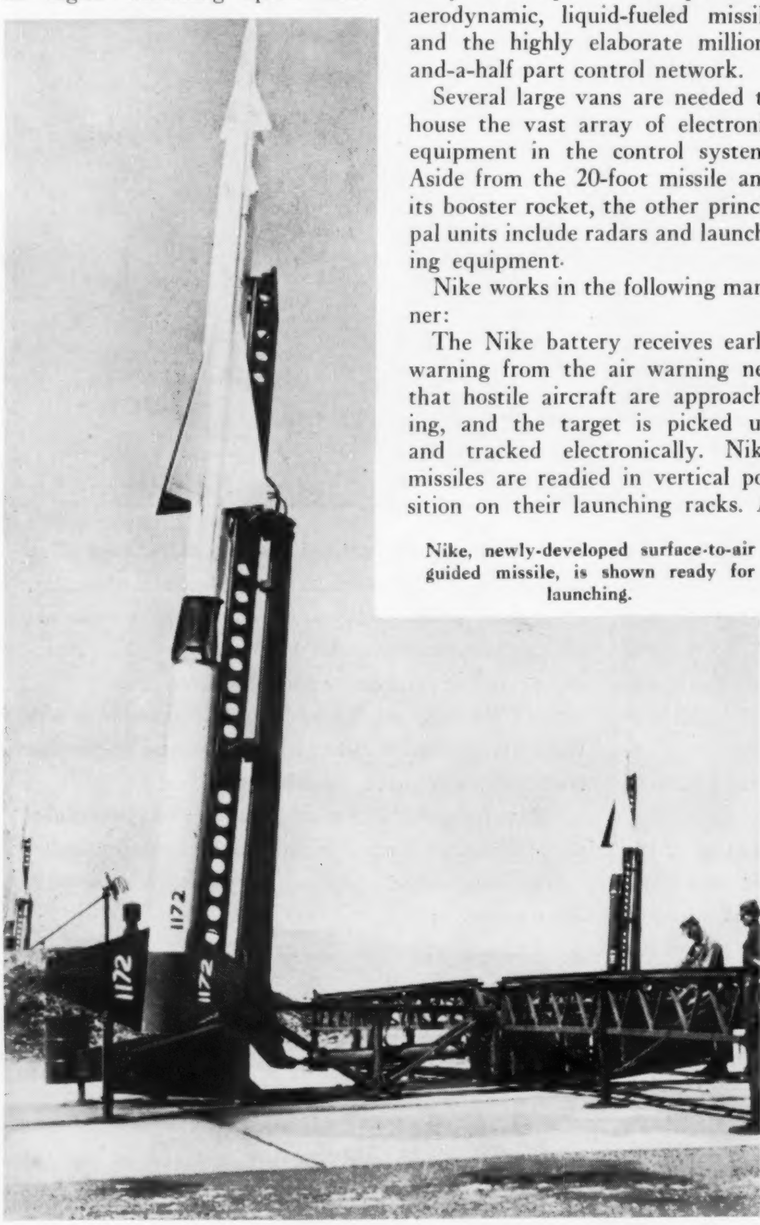
WORTHINGTON

The Sign of Value Around the World

Technibriefs

Consisting of more than 1,500,000 individual parts, the dramatic Nike, with its approximately 300 highly complex electronic "brain cells," is the first surface-to-air-guided missile system to be put into service around U. S. cities.

Nike is the answer to Army Ordnance's call for a new defensive weapon that will meet an aerial target in its own element and on its own terms. Such a weapon has to be highly maneuverable throughout its flight. Matching speed with speed would not be sufficient, since the initiative would remain with an enemy plane.



Nike, newly-developed surface-to-air guided missile, is shown ready for launching.

The end product of eight years' guided missile research, Nike is the only supersonic anti-aircraft missile thus far announced that can follow and destroy an enemy target despite its evasive action. Essentially a defensive weapon, the Nike system is highly mobile and will work in any weather—even when visibility is zero. The system consists essentially of two parts: an expendable aerodynamic, liquid-fueled missile and the highly elaborate million-and-a-half part control network.

Several large vans are needed to house the vast array of electronic equipment in the control system. Aside from the 20-foot missile and its booster rocket, the other principal units include radars and launching equipment.

Nike works in the following manner:

The Nike battery receives early warning from the air warning net that hostile aircraft are approaching, and the target is picked up and tracked electronically. Nike missiles are readied in vertical position on their launching racks. A running account of the target's changing position is transmitted to the control center. As the target crosses an invisible deadline the Nike missile is fired. The complex electronic equipment guide the missile so that it intercepts the target and explodes on contact.

The new system and accompanying radar equipment is currently being mass produced from Army Ordance by Western Electric, the manufacturing and supply unit of the Bell System.

Wafers for Transformers

Important advances in the design and production of power transformers through the application of a new type of transformer coil have been developed by Sylvania Electric Products Inc.

This advance is in the form of wafer-type transformer coils which are made by rolling together wide sheets of metal foil and insulating paper. The rolls are then sliced into wafers resembling minature life preservers. New systems have also been developed which will allow facile assembly of individual wafer-coils into the completed coil unit.

The use of wafer-coils in small power transformers results in reduced size, greater uniformity, and cooler operating temperatures. Cost saving is also attained through the high degree of automation which can be attained by the wafer-coil technique. The wafer-coil technique may be conveniently applied to the small, electronic type of transformers and also to the power field.

"Piano roll" machine tools

Telegraphing spare parts all over the world is the interesting possibility engineers see for tape-controlled automatic machine tools.

Employing the principle of the player piano roll—holes punched on a tape—lathes and other machine tools can be made to follow a pattern to reproduce parts automatically and in great quantities. If the pattern information can be put on teletype tape, it can be telegraphed to distant places to control machine tools on the spot.

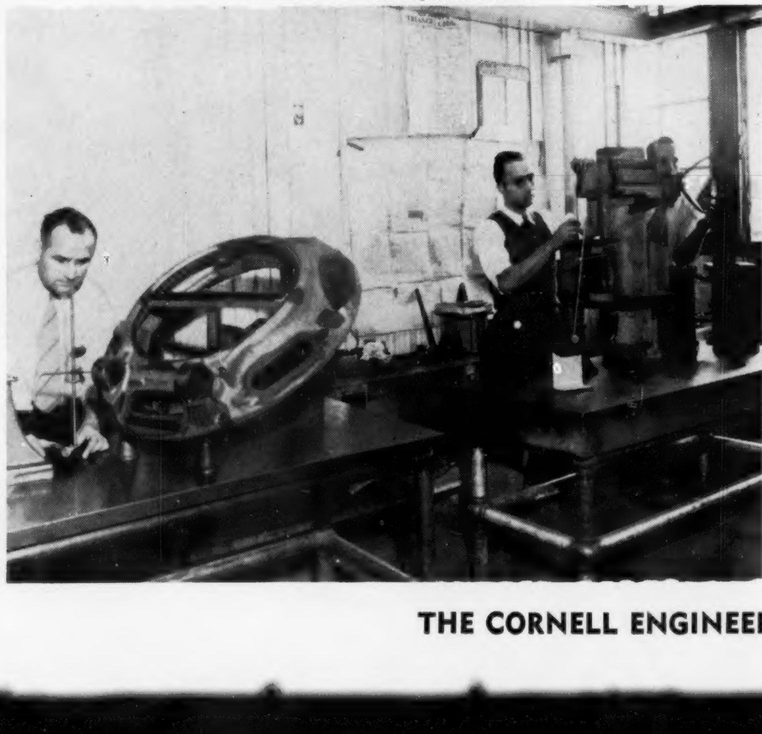
A segment of the Western Electric assembly line where complex electronic components of the Nike control system are made. More than 300 "brain cells" similar to the one shown are used to track the target and automatically guide the missile to it.

The principle of controlling machines by tape or by film has been in the process of development for 150 years. About 1804 a loom was invented that was controlled by punched cards linked together in a chain. The control device was applied to embroidery machines and to lace-making machines. Similar systems are used on player pianos and organs and on typesetting machines.

In the machine tool field, the problems are somewhat different than on the earlier devices. Most of these machines employ a hole in the tape for a particular operation or location. On the player piano, the presence of a hole causes a particular note to be struck. On the loom, a hole in a selected location will raise a particular thread.

Using a tape system on a machine tool, when orders come in for spare parts, the tape is taken out of the file and put in the machine. The op-

Checking sample castings for conformity to blue prints or pattern dimensions. This is a standard procedure in steel foundries producing under Recommended Minimum Standard or other specifications.



erator does not even need to know what the fachine is going to make. All he has to know is what size of stock to put in and where to put it.

For simple pieces, the tapes are made in the user's plant. If the pieces are exceptionally complicated the tapes can be prepared on large modern computing machines.

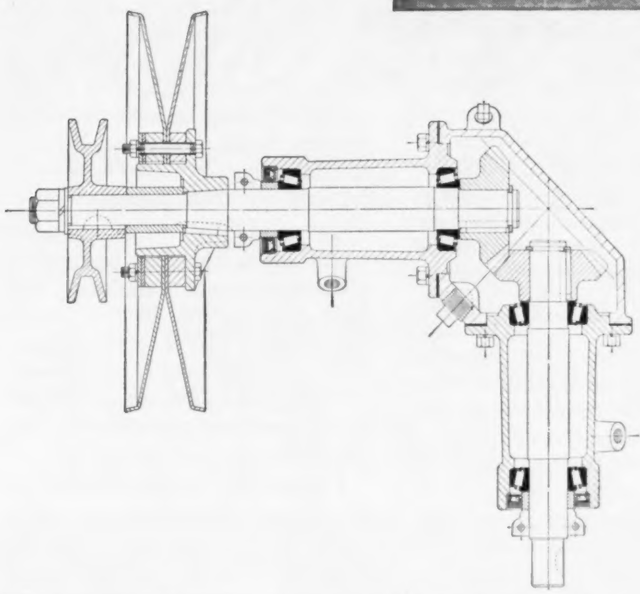
Another Use For Cellulose

A new and inexpensive method for curing concrete test cylinders in the field under controlled humidity and temperature conditions has been developed. Under the new method, test cylinders are placed in a ruggedly constructed metal curing can, lined with a thick layer of Du Pont cellulose sponge. This inner liner is the most important part of the curing can since it permits the absorption of two to four quarts of water with a 60 per cent retention at seven days. The bottom of the can has a special gasket that insures a complete seal when the top is in place.

With this equipment, concrete test cylinders can be cured satisfactorily in a field laboratory dur-

(Continued on page 44)

Another page for **YOUR BEARING NOTEBOOK**

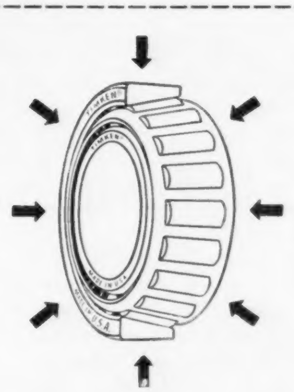


How to increase bevel gear life

The shafts that hold the bevel gears in this farm machine gear box carry two kinds of loads. Loads from the bevel gears run 1) along the shaft and 2) at right angles to it. Timken® bearings, being *tapered,* carry both loads at once, hold gears rigidly in place. Perfect tooth-mesh is maintained; gears last longer.

How TIMKEN® bearings hold shafts rigid

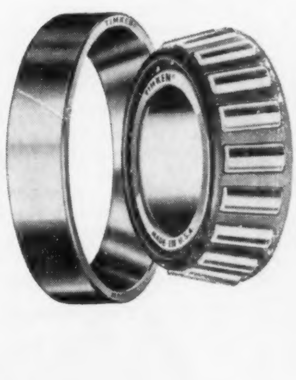
The line contact between rollers and races of Timken bearings gives shafts rigid support over a wide area. Shaft deflection is minimized. And end-play is eliminated because the tapered design of Timken bearings lets them take radial and thrust loads in any combination.



TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



Want to learn more about bearings or job opportunities?

Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

NOT JUST A BALL ○ NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

Helicopters

(Continued from page 12)

on the basis of experience, aircraft size and configuration, and type of intended operation.

One form of pitch-control ("cyclic pitch control") is illustrated in figure 5. All present-day helicopters employ cyclic pitch control. Collective pitch control is accomplished by raising and lowering the "swash plate"; and cyclic control, by tilting the swash plate. Hub geometry is an important factor, subject to much study and model-testing.

The chief mechanical design problem which has plagued articulated systems, and hubs in general, has been deterioration of bearings under high, oscillating loads; the solution has been sought in improved bearings with closer fits and frequent lubrication, with some success. But the problem still remains.

Blade Construction

An especially interesting series of improvements has taken place in the field of rotor blade construction and has been reported during the last several years by manufacturers and members of research organizations. Choice of blade material is one of the major items of controversy in the "art", and several examples exist of all-wood, all-metal, and stressed metal skin designs being flown with excellent results. Recently another new type of blade, built of fiberglass laminate, has been designed and manufactured by CAL. This design was introduced in 1949 and has since had considerable success.

Historically, the first successful kind of lifting rotor was built of tapered central metal spars having wooden (usually plywood) ribs attached at about two-inch intervals, and covered with a heavy dope-stressed fabric. Little attention is now given fabric blades. Their disadvantage is that under high aerodynamic pressures the fabric tends to distort between the ribs and spoil the airfoil's lift, or at least increase the drag power losses.

The standard form of all-metal blade consists of lengthwise extruded or rolled aluminum sections, reinforced centrally by a web. The blades have been found good in that they are insensitive to changes in atmospheric humidity, have a rigid profile, and may be built to desired stiffness ratios, chordwise balance, and other specifications with comparative ease in mass production.

On the other hand, all-wood blades are cheaper, can be repaired without the use of special tools, and have generally the longest service life of any blades existing now. Their high-density construction makes them able to withstand rough handling, impact loads, rain and hail.

The Cornell fiberglass blades allow a great deal of scope for variations. Originally they consisted of a balsa core covered with several layers of glass cloth impregnated with a plastic cooked on in a blade-shaped mold. The root end of the

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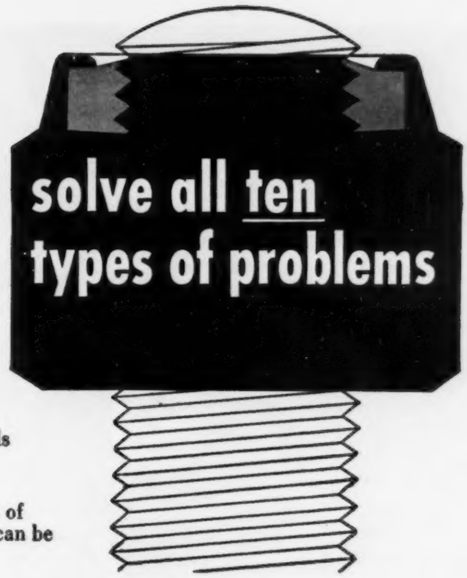
elastic stop nuts solve all ten types of problems



Here are ten typical fastening problems. One device, the ELASTIC STOP nut, solves them all—without additional parts or operations. Deliberately undersized in relation to bolt diameter, the red elastic collar grips the bolt with a perfect fit, exerting a continuing self-locking pressure against the threads, and holding the nut securely in place at any point on the bolt. It also provides a tight seal against the bolt threads, which prevents seepage and wear-producing axial play. And because the bolt threads are protected against moisture from without, the nuts are not "frozen" to the bolt by corrosion.

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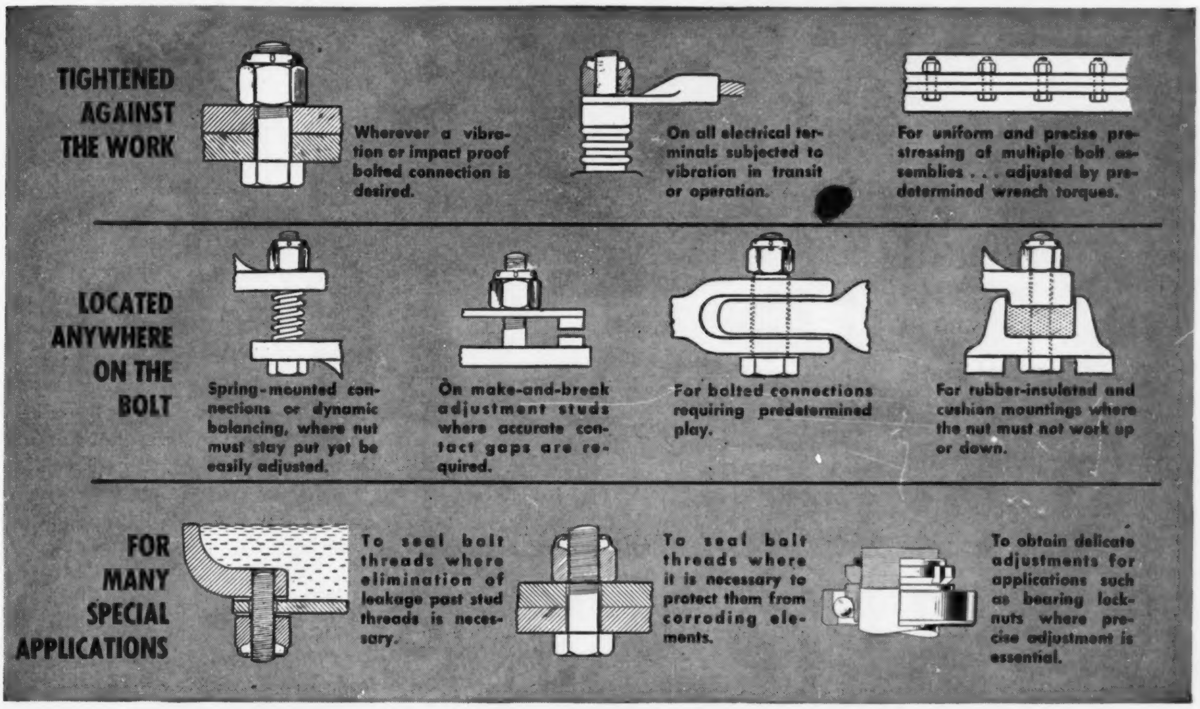

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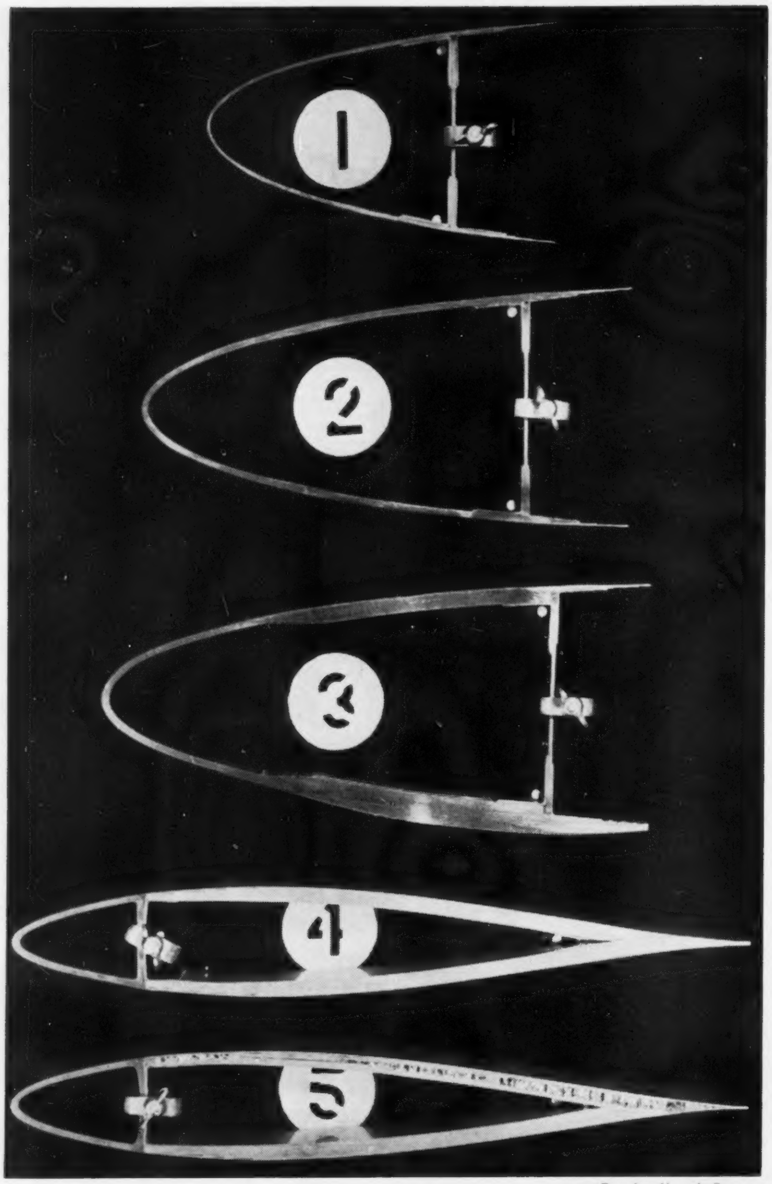

—*Prewitt Aircraft Company*

Fig. 6. Laminated metal blades which involve metal-to-metal bonding. Bonding is done at elevated temperatures with solid backing on the outside and pressurized fluid in the inside. (1) Tip section of blade with 28-inch chord and 37-foot length; (2) a mid section; (3) and (4) root sections; (5) section of a blade 12 inches from root.

Helicopters

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blade was dovetailed into a spruce reinforcement section. The first work on this design, reported by former CAL director Harold Hirsch at the American Helicopter Society, indicated that the potentialities of the molded fiberglass design were sufficiently great to call for additional development.

Manufacturing tolerances in blades have been the headache of engineers for some time, due to the need for extreme dependability, close design, ad inevitable production errors, such as scratches, which tend to make the service life somewhat less (often a lot less) than the "infinite" design life. For this reason, continued study of construction materials is rendered necessary for advanced quality rotor systems.

It should be remarked, in conclusion, that the summary presented in the foregoing article is by no standards complete, for at the present time many of the current helicopter research projects carry a military classification. Among such projects, for instance, are improved ramjet-powered rotor systems.

Technibriefs

(Continued from page 40)

ing the hot summer. After the cylinders are prepared in accordance with A.S.T.M. procedure, the sponge liner in the curing can is thoroughly saturated with water. Test cylinders are then placed in the bottom of the can and covered —the saturated condition of the cellulose sponge liner assuring adequate humidity for proper curing. This also eliminates the high concrete temperatures developed from the heat of hydration, plus atmospheric conditions.

During winter field operations, the liner is used in a dry condition and greatly eliminates the retarding of proper curing due to low temperatures.

Lifeboats Get Radios

A new portable lifeboat radio, designed to withstand rough emergency service and the corrosive effects of salt water, is using tetrafluoroethylene resin to overcome an "Achilles heel" problem.

The two-way communication system is housed in a casing of anodized aluminum, with neoprene gasketing around the controls. Buoyed up by the enclosed air which cannot escape past the neoprene gaskets, the radio floats when cast into the sea. Conventional materials with adequate insulating properties for the antenna post failed, however, in this rough service through cracking, chipping, and deterioration caused by salt spray. The re-designed antenna post made of "Teflon" is unaffected by the corrosive conditions of storage and service and has sufficient resilience to withstand rough handling and abuse without cracking.

Telegraph

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an Inspection Group and attempts to assume the functions of a Quality Control Organization. This is a "cradle to the grave" concept for product manufacture, guarding the quality of the product from its initial conception, through its evolutionary period of manufacture, and to its final emergence as a finished product.

STRESS *and* STRAIN...

Class Reunion: Mixing of old grad with Old Granddad.

* * *

They laughed when I came with shorts on, but when I sat down they split.

* * *

And then there is the attorney who sat up all night trying to break a widow's will.

* * *

Today's Greatest Labor Saver: Tomorrow.

* * *

And as they say in Mechanics—"Every couple has its moment."

* * *

EE: "What's that crawling up the wall?"

ChemE: "A lady bug."

EE: "Man, what crazy eyesight."

* * *

"Gas overcomes girl while taking bath" read a headline in a Bowling Green, Ky., paper. Then followed the account of a near tragedy: "Miss Blank owes her life to the watchfulness of the elevator boy and the janitor."

* * *

Faculty joke overheard at Summer Survey Camp: These students are a lot like mummies—pressed for time.

* * *

Son: Why does Mom call Uncle Pete college-bred?

Dad: Because he just finished a four year loaf.

Daughter: "I took Henry into the loving room last night and . . ."

Mother: "That's LIVING dear."

Daughter: "You're telling me!"

* * *

He: "Whisper those three little words that will make me walk on air."

She: "Go hang yourself."

* * *

And then there was the E.E. who called his girl "Carbon" because her resistance went down when she got warmed up.

* * *

"Do you know who was the first engineer?"

"No, who?"

"Adam, he furnished spare parts for the first loud speaker."

* * *

"I just knocked a P-Chem test cold."

"Really?"

"Yeah, absolute zero."

* * *

Lectures are like steer horns—a point here, a point there, and a lot of bull in between.

* * *

He: "Sir, may I have your daughter for my wife?"

Father: "Bring your wife around and I'll see."

* * *

"Mother, are there any skyscrapers in heaven?"

"No, son, it takes engineers to build skyscrapers."

* * *

A pink elephant, a green rat, and a yellow snake walked into Zinck's.

"You're early, fellows," said the bartender. "They aren't here yet."

Teacher: "What does f-e-e-t spell?"

Student: "I don't know."

Teacher: "What does a cow have four of that I have only two of?"

Student's answer resulted in such a commotion that the class broke up and left the teacher a nervous wreck.

* * *

He: "Would you commit adultry for a million dollars?"

She: "Why, yes, I think I would."

He: "Would you commit adultry for two dollars?"

She: (Shocked) "Oh, what do you think I am?"

He: "We've settled that. What we're haggling about is the price."

* * *

CE (in bookstore): "How much is this paper?"

Clerk: "Seventy-five cents a ream."

CE: "It sure is."

* * *

Poetry . . .

Both women and pianos
Are similar in brand . . .
Some of them are upright
And some of them are grand . . .

* * *

A young engineer took his girl to the open air opera one beautiful warm sunny evening. During the first act he found it necessary to excuse himself. He asked the usher where the men's room might be found.

"Turn left, and walk down to the big oak tree, and there it is."

The young engineer did as he was told and in due time returned to his seat.

"Is the second act over yet?" he asked his girl.

"You ought to know," she replied, "you were in it."

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